

An Account of the Species of *Polysiphonia* of the Central and Western Tropical Pacific Ocean

I. *Oligosiphonia*¹

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ABSTRACT: Twenty-four tetrasiphonous species are described. The following species or varieties are new: *Polysiphonia anomala*, *P. apiculata*, *P. delicatula*, *P. flaccidissima* var. *decimera*, *P. flaccidissima* var. *iki*, *P. flaccidissima* var. *lopi*, *P. hawaiiensis*, *P. herpa*, *P. poko*, *P. poko* var. *longii*, *P. profunda*, *P. pseudovillum*, *P. quadrata*, *P. rubrorhiza*, *P. setacea*, *P. sphaerocarpa* var. *distans*, *P. sphaerocarpa* var. *filifera*, *P. subtilissima* var. *abbottae*, *P. tenuis*, *P. tuberosa*, *P. scopulorum* var. *macrotrichia*, *P. scopulorum* var. *minima*. The following new combinations are made: *P. saccorhiza* (Collins and Hervey) comb. nov., *P. sparsa* (Setchell) comb. nov., *P. scopulorum* var. *villum* (J. G. Agardh) comb. nov., *P. mollis* var. *tongatensis* (Harvey) comb. nov.

THIS PAPER includes the results of studies made in 1962 of Dr. Maxwell Doty's collection of marine algae at the University of Hawaii, and of collections made by the author during 1948 in the Marshall Islands and in 1964-1965 of collections by Doty from widely scattered islands of the central and western tropical Pacific Ocean.

The taxonomically important features of the genus *Polysiphonia*, such as the number of pericentral cells, cortication, the nature and arrangement of trichoblasts, the origin of branches in relation to trichoblasts, and the nature of the spermatangial branches were pointed out in previous papers (Hollenberg, 1942a, 1942b, 1944, 1961) and still earlier by Falkenberg (1901) and others. Also it was previously recognized that the connection between the rhizoids and the pericentral cells bearing them is a feature of dependable taxonomic value. Not sufficiently recognized in earlier work on the genus is the nature of the apex of the rhizoids. In general the writer's observations indicate that the length and abundance of rhizoids and whether or not the tip is digitate is a variable feature for a given species, dependent largely on the nature

of the substratum and to some extent on the proximity of other plants or branches of the same plant. The degree of development of trichoblasts and their persistence is likewise a variable feature in most species.

On the other hand the development of multicellular rhizoids, by cutting off a series of cells from the apex, seems to be a more constant feature of considerable taxonomic importance. Although in some species gradations may occur, in general in mature rhizoids the apex is either clearly multicellular or simple to merely digitate in a given species when in contact with a firm substratum. Also the point of origin of rhizoids is characteristic for certain species. It was previously pointed out (Taylor, 1945:302) that the rhizoids arise mostly on the distal end of the pericentral cells (nearest the branch tip) in *P. howei*, as they seem to do in all species of *Herposiphonia*, whereas in most species of *Polysiphonia* they arise on the proximal end or from the center of the pericentral cell.

Three species, *P. scopulorum*, *P. sparsa*, and *P. saccorhiza*, formerly considered as species of *Lophosiphonia* are included in this paper. In a former paper (Hollenberg, 1942a) it was concluded best to follow Setchell and Gardner (1903) in placing *P. villum* J. G. Agardh in the genus *Lophosiphonia* even though in a number of species of *Polysiphonia*, which are not chiefly prostrate in habit, erect branches com-

¹ Species with five or more pericentral cells will be treated in a later paper. This study was made possible through the support of research grant No. GB-2735 of the National Science Foundation.

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monly arise endogenously from the prostrate branches. The chiefly prostrate habit has often in practice been almost the sole criterion for distinguishing *Lophosiphonia* from *Polysiphonia*. Kylin (1956) emphasized another feature characteristic of many species generally placed in the genus *Lophosiphonia*, a feature which was included in the original description of the genus. This feature, the dorsiventrality of the shoot apex, is well exemplified in *L. cristata* Falkenberg, in which trichoblasts are unilateral.

However, dorsiventrality may be determined by various factors in addition to the habit and manner of origin of erect branches from prostrate branches, or the unilateral branching of erect branches. In certain species of *Polysiphonia* short and more or less determinate erect branches arise cicatrigenously from spirally arranged primordia resembling scar-cells on the prostrate branches. Such prostrate branches are certainly not basically dorsiventral in spite of the seemingly dorsiventral habit. Furthermore, in certain species of *Polysiphonia* the first formed pericentral cell of a given segment is directly distal to or above the first formed pericentral cell of preceding segments. This is one type of dorsiventrality (unilaterality), and in such species the tetrasporangia likewise develop in a straight row rather than in a spiral arrangement as in most species. However, in species in which the tetrasporangia are in nonspiralling rows, the trichoblasts, if present, are spirally and not unilaterally arranged. In such cases one is at a loss to decide whether the apex of erect branches is radial or bilateral in construction unless one designates the determining feature or features.

Accordingly, the writer is presently of the opinion that the genus *Lophosiphonia* should include only those species which have the following features: (1) chiefly prostrate habit, (2) endogenous origin of erect, mostly simple, and more or less determinate branches from the prostrate branches; and (3) dorsiventral or bilateral apex of all branches, as evidenced by unilateral origin of either lateral branches or trichoblasts on the erect branches, or both.

In the following account when the positions of trichoblasts are described as "one per segment" this indicates an arrangement in which more accurately a trichoblast or a scar-cell occurs

on each segment not bearing a branch. It should also be noted that branches sometimes appear to arise in connection with trichoblasts when in fact they arise, as is frequently the case in *P. tuberosa*, in a delayed exogenous manner from the primordial cell which bears the trichoblast before the latter is shed.

The following symbols indicate the chief collectors of the materials studied: Da., E. Y. Dawson; D., Maxwell S. Doty, University of Hawaii; G., Malvern Gilmartin Jr., University of Hawaii; H., G. J. Hollenberg; H., T., and B., G. Hollenberg, Roy Tsuda, and R. Buggeln; L., C. R. Long, graduate student at the University of Hawaii; and T., Roy T. Tsuda, graduate student at the University of Hawaii at the time.

All D. collections were made by Maxwell S. Doty unless otherwise indicated. Further ecological data concerning collections at the University of Hawaii are given in his notebooks. Most of the dredged materials from Hawaii with Doty numbers were from collections made by Tetsue Matsui on the Pele Expeditions sponsored by Mrs. Mary Eleanor King and the Bernice P. Bishop Museum.

Relatively few dried herbarium mounts of *Polysiphonia* from the areas concerned are available for study. Furthermore, it is very difficult to make dependable determinations of most of these small algae from dried materials. Hence exsiccata have been studied to only a limited extent and mostly in the study of types or otherwise authentic material. Herbarium specimens examined other than types are indicated as follows: BISH, Bishop Museum, Honolulu, Hawaii; C, University of California, Berkeley.

The chief areas represented in the study are treated in the following sequence with the following approximate latitudes and longitudes: Midway Island (28°N, 177°W); Hawaiian Islands (19–28°N, 155–176°W); Johnston Island (16°N, 169°W); Line Islands (2–7°N, 157–162°W); Marquesas Islands (10°S, 140°W); Tuamotu Archipelago (25–16°S, 130–150°W); Phoenix Islands (5–7°S, 170–174°W); American Samoa (13–14°S, 168–170°W); Fiji Islands (15–21°S, 178°W to 176°E); Gilbert Islands (2–3°N, 172–177°E); Marshall Islands (4–14°N, 161–

171°E); Caroline Islands (4–8°N, 49–140°E); Philippine Islands (5–20°N, 120–127°E).

All types will be stored at the Smithsonian Institution, Washington, D.C. Isotypes or syntypes and hundreds of glucose microslide mounts representing nearly every listed collection and some not listed in the following account will be stored at the University of Hawaii.

Most of the species from the tropical Pacific area are small to minute. Species occurring in harbors and similar locations are somewhat larger. Those from small remote islands such as Johnston Island are notably smaller than those from larger land masses. It seems likely that availability of micronutrients may be a factor related to plant size.

KEY TO THE SPECIES OF *Polysiphonia*

1. With 4 pericentral cells 2
1. With more than 4 pericentral cells (Part II of this study) 26
2. Main branches corticated, at least at the base *P. hancockii*
2. All branches without cortication 3
3. Rhizoids large, saccate, and prominently pigmented 4
3. Rhizoids not pigmented 5
4. Chiefly erect from a basal tuft of rhizoids *P. rubrorhiza*
4. Chiefly prostrate, with distributed rhizoids *P. saccorbiza*
5. Median parts of erect branches mostly 200 μ or more in diameter 6
5. Median parts of erect branches mostly 150 μ or less in diameter 9
6. Fruiting branches prominently narrowed at the base *P. beaudetii*
6. Fruiting branches not prominently narrowed at the base 7
7. Commonly 3–5 cm high, with branches mostly widely divaricate and with branch tips more or less dichotomously branched *P. hawaiiensis*
7. Mostly less than 2 cm high, branches not widely divaricate 8
8. Segments in branch tips very short for many segments back of tapering apices; branching mostly alternate above *P. sparsa*
8. Segments in branch tips otherwise; branching more or less pseudodichotomous at apices *P. sphaerocarpa*
9. Erect branches with a trichoblast, a scar-cell or a branch at every segment except those near the base of a branch 10
9. Erect branches with frequent to numerous segments without a trichoblast, a scar-cell or a branch (mostly on each segment in *P. tenuis* and *P. delicatula*) 20
10. With limited to extensive prostrate branches 11
10. Attached by a basal tuft of rhizoids, with usually no creeping branches; plants epiphytic .. *P. savatieri*
11. With prominent prostrate branches and with erect branches simple or with only a few lateral branches 12
11. Chiefly erect and branched, with mostly limited prostrate branches 16
12. With no scar-cells on prostrate branches *P. tenuis*
12. With scar-cells on prostrate branches 13
13. Scar-cells on prostrate branches divided into a group of small cells *P. herpa*
13. Scar cells mostly undivided 14
14. Erect branches 50 μ or less in diameter 15
14. Erect branches 100 μ or more in diameter *P. poko*
15. Erect branches mostly less than 1 mm high, with relatively huge trichoblasts *P. anomala*
15. Erect branches commonly 2 or more mm high; trichoblasts relatively small *P. delicatula*
16. Branches arising apically in connection with trichoblasts 17
16. Branches not arising in connection with trichoblasts 18
17. Trichoblasts colorless quickly deciduous; erect branches 1–3 cm high *P. flaccidissima*
17. Trichoblasts brownish, relatively persistent; erect branches 3–6 mm high *P. profunda*
18. Plants mostly of sheltered and often semibrackish water, more than 3 cm high; segments of median parts of erect branches mostly 2 or more diameters long *P. mollis*
18. Strictly marine plants of open water, less than 3 cm high; segments of median parts of erect branches mostly less than 1.5 diameters long 19
19. Sublittoral plants, with branch apices abruptly acute to apiculate; tetrasporangia not protuberant *P. apiculata*

- 19. Mostly littoral plants, with branch apices not abruptly pointed; tetrasporangia protuberant (in certain varieties) *P. sphaerocarpa*
- 20. Rhizoids cut off by a cross-wall from the pericentral cells 21
- 20. Rhizoids remaining in open connection with the pericentral cells 25
- 21. Mature rhizoids mostly with multicellular apices, arising at the distal end of the pericentral cells
..... *P. setacea*
- 21. Mature rhizoids unicellular, although often digitate, arising mostly at the proximal end of the pericentral cells 22
- 22. Erect branches regularly branched 23
- 22. Erect branches mostly unbranched 24
- 23. Branches arising apically in a typically exogenous manner; erect branches commonly 1 cm or more high *P. upolensis*
- 23. Branches arising subapically in a delayed exogenous manner; erect branches mostly less than 1 cm high; prostrate branches frequently with tuberous portions *P. tuberosa*
- 24. Segments of erect branches 1.2–1.5 diameters long in median parts; trichoblasts at intervals of 1–2 segments *P. pseudovillum*
- 24. Segments of erect branches mostly 0.5 diameter long or shorter; trichoblasts at intervals of 4–8 or more segments *P. quadrata*
- 25. Plants of mostly brackish water, mostly 3 or more cm high, with numerous branches
..... *P. subtilissima*
- 25. Strictly marine plants, mostly saxicolous, and less than 1.5 cm high; erect branches simple or occasionally branched *P. scopulorum*

Polysiphonia anomala sp. nov.

Figs. 1A, 1B, 1C

Extremely minute algae with creeping branches 30–40 μ in diameter, composed of segments 1.0–1.5 diameters long, attached by frequent unicellular rhizoids, which are cut off as separate cells from near the center of the pericentral cells; erect branches arising cicatrigenously at frequent intervals, unbranched, to 1.5 mm high but mostly much shorter, similar to the prostrate branches, but with segments mostly shorter than the diameter; pericentral cells 4, ecorticate; trichoblasts on erect branches relatively huge to 1.1 mm long, arising one per segment in $\frac{1}{4}$ spiral sequence, with 3–4 dichotomies and long tapering tips, mostly soon shed; scar-cells relatively large, 9–11 μ in diameter, occurring one per segment in $\frac{1}{4}$ spiral sequence on prostrate as well as erect branches; tetrasporangia in short spiral series in the terminal parts of erect branches, which are prominently distended in fruiting segments; cystocarps ovate to slightly urceolate, 120–140 μ in diameter, with cells of the ostiolar rim not much enlarged, arising terminally on very short erect branches; spermatangial branches unknown.

Algae minutissimae, praecipue prostratae, ramos repentes 30–40 μ diam., per rhizoidea unicellularia, ut cellulas discretas separata affixos, et ramos erectos cicatrigenosos, saepissime breviores quam 1 mm alt.,

habentes; cellulae pericentrales 4, ecorticatae; trichoblastae relative immensae, ad 1.1 mm alt., 3–4 dichotomias habentes, una in unoquoque segmento in ramis erectis, cito deciduae; cellulae-cicatrices magnae, una in unoquoque segmento, in $\frac{1}{4}$ spira in ramis prostratis erectisque; tetrasporangia in serie spirali brevi in ramis erectis brevibus; cystocarpi ovati ad paululum urceolatos in ramis erectis brevissimis terminales; rami spermatangiales ignoti.

TYPE: H. 48–1213.19, cystocarpic, growing on a species of *Microdictyon*, Amen I., Bikini Atoll of the Marshall Islands, July 7, 1948. It is represented by a glucose slide mount and fluid-preserved material.

OTHER COLLECTIONS: H. 65–105, from a depth of 1–2 m north of North I., Johnston I., legit R. S. Jones, Apr. 22, 1965; H. 48–1609.B, cystocarpic, from coral reef several miles north of the north end of Bikini Island, Bikini Atoll, July 12, 1948; D. 9608B, tetrasporic, on *Liagora* sp. legit Leonard Horwitz, Arno Atoll, Marshall Islands, July 1, 1951; L. 2628.7, tetrasporic, on *Halimeda* sp., Phoenix I., Phoenix Group, Nov. 6, 1964.

P. anomala is commonly found on species of *Microdictyon* along with *P. delicatula*. Both species are delicate creeping forms. *P. anomala* differs from *P. delicatula* in the much shorter erect branches, huge trichoblasts, and much larger scar-cells, and in the procarps and cysto-

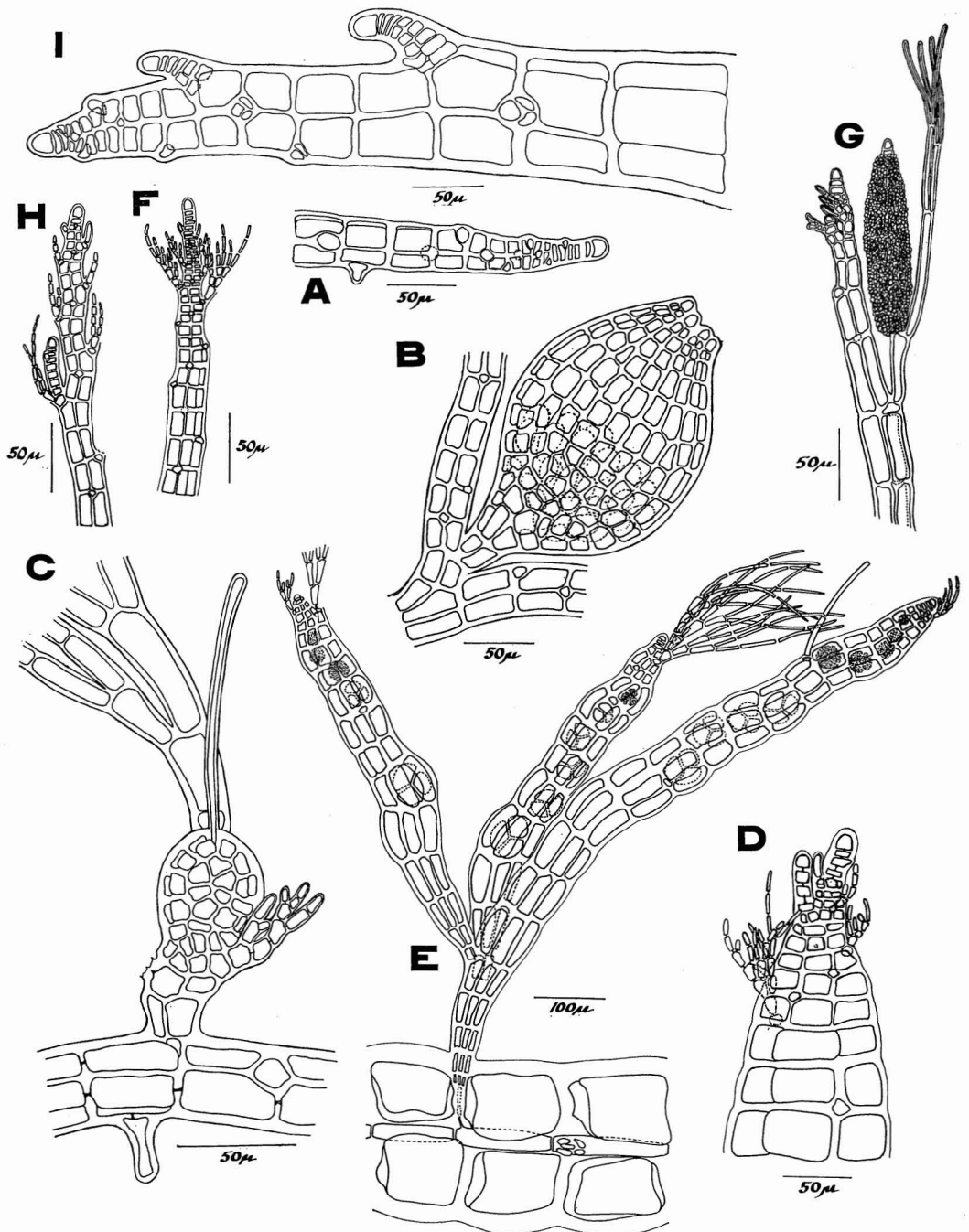


FIG. 1. A, *Polysiphonia anomola*, apex of a prostrate branch. B, *Polysiphonia anomola* cystocarp. C, *Polysiphonia anomola*, young cystocarp on a very short erect branch, bearing a huge trichoblast. D, *Polysiphonia apiculata*, apex of a branch. E, *Polysiphonia beaudettii*, with tetrasporangial branches narrowly attached to a main axis. F, *Polysiphonia delicatula*, apex of erect branch. G, *Polysiphonia flaccidissima* var. *iki*, apex of a branch bearing a spermatangial stichidium. H, *Polysiphonia flaccidissima* var. *lopi*, branch apex. I, *Polysiphonia herpa*, apex of prostrate branch showing origin of erect branches from dorsal primordia.

carps arising on very short pedicels on the creeping branches.

It should be noted here that a very similar alga was collected by E. Y. Dawson, number 7472, tetrasporic, from Lake Surprise, Key Largo, Florida, May 28, 1949. The Florida alga corresponds closely with the Pacific species as far as known, with certain exceptions, namely: (1) the Florida specimens are seemingly less firmly attached to the substratum; (2) trichoblast primordia or scar-cells do not occur regularly one per segment on the prostrate branches as they do in *P. anomala*, but at irregular and less frequent intervals; (3) the indeterminate (prostrate) branches are somewhat larger in the case of the Florida specimens; (4) tetrasporangia often occur in the indeterminate branches in series of 10–12 somewhat back of the apex.

In spite of these differences it seems best for the present to identify the Florida plant with *P. anomala* on account of the general features, and especially the short and more or less determinate erect branches arising from much more extensive creeping branches, the very large and much branched trichoblasts, and the rhizoids, which are cut off as separate cells from the pericentral cells.

Polysiphonia apiculata sp. nov.

Figs. 1D, 8, 9

Plants mostly sublittoral, epiphytic, up to 2.0 cm high, with a limited basal attachment by a number of unicellular rhizoids, which are cut off as separate cells from the basal end or middle of the pericentral cells; main branches 150–250–(320) μ in diameter, composed of segments mostly 0.5–1.0 diameter long; branching pseudodichotomous, replacing trichoblasts at intervals of 7–14–(20) segments; ultimate branches non-tapering for most of their length, but abruptly narrowed and more or less apiculate terminally; pericentral cells 4, ecorticate, trichoblasts mostly very rudimentary, occasionally 260–740 μ long and 17 μ in diameter at the base, with 3–4 dichotomies, arising one per segment in $\frac{1}{4}$ spiral sequence, soon deciduous leaving very small scar-cells; tetrasporangia up to 60 μ in diameter in slightly spiral series in the ultimate branches, whose segments are scarcely or not at all distended; pericarp globular, 240–

320 μ in diameter, composed of relatively large cells, with the cells of the ostiolar rim not much enlarged; spermatangial branches (immature) arising as a primary fork of a trichoblast.

Plantae epiphyticae, ad 2 cm alt., affixionem basalem praefinitam per rhizoidea, ut cellulas discretas separata, habentes; rami principales plerumque 150–250 μ diam., segmentis 0.5–1.0 plo breviora quam lata habentes; rami pseudodichotomi, intervallis 7–14–(20) segmentorum, pro trichoblastis substituitui; rami ultimi abrupte angustati, ad apicem plus minusve apiculati; cellulae pericentrales 4, ecorticatae; trichoblastae plerumque elementariae, 3–4 furcas habentes, una in unoquoque segmento in $\frac{1}{4}$ spira enascente, mox decidua; cellulae-cicatrices minutae; tetrasporangia in serie paululum spirali, non protuberantia; cystocarpi globosi, cellulis orae ostiolaris vix amplificatis; stichidia spermatangialia ut furca primaria trichoblastae enascentia.

TYPE: D. 19127p, tetrasporic, dredged 10–14 fa, Pokai Bay, Oahu, Hawaii, July 30, 1959; represented by a glucose mount.

ADDITIONAL COLLECTIONS: HAWAIIAN ISLANDS—D. 19144AE1, on *Amansia*, D. 19144AV2, tetrasporic, cystocarpic, D. 19144C2, tetrasporic, cystocarpic, on *Galaxaura* sp., D. 19144M1, on *Laurencia* sp., D. 19144Q2, spermatangial, D. 19145J1, tetrasporic, cystocarpic, on *Laurencia*, all dredged 6–13 fa, Port Allen, Kauai, Sept. 12, 1959; D. 19136K1, spermatangial, washed ashore north of Koloa Stream, Oahu, Apr. 15, 1956; D. 19115C1, dredged 20 fa, east of Explosive Ammunition Area, Oahu, Sept. 15, 1959; D. 19118C1, on *Amansia* sp., dredged 16–25 fa, Pokai Bay, Oahu, July 30, 1959; D. 19122D1 and D. 19124R, dredged 15–25 fa, Pokai Bay, Oahu, July 30, 1959; D. 19126J1, dredged 20–25 fa, Pokai Bay, Oahu, July 29, 1959; H. 65–14, cystocarpic, dredged 2–3 fa, Kaneohe Bay, Oahu, Mar. 20, 1965; LINE ISLANDS—Da. 20016 (as *P. mollis* Hooker and Harvey), immature spermatangial, adrift northeast side of Clipperton I., Aug. 1958; MARSHALL ISLANDS—H. 48–0290.3, on *Laurencia* sp., inner reef, lagoon side of Eric I., Bikini Atoll, July 13, 1948; CAROLINE ISLANDS—D. 21857.1, tetrasporic, cystocarpic, on other algae, on reef flat, Yap I., legit E. Menez, Aug. 18, 1960; PHILIPPINE ISLANDS—collection by D. P. Abbott, on *Halimeda* sp., cystocarpic, Pasig Bay, Balabac I., Mar. 3, 1957.

Polysiphonia beaudettii Hollenberg (1961:348)
Figs. 1E, 17

Plants epiphytic, to 4 cm or more high, with main erect branches to 700 μ in diameter at the base, with distinct main axes and infrequent lateral branches, attached basally by a tuft of unicellular rhizoids with digitate tips and cut off by a cross-wall from the pericentral cells of 2–3 basal segments; pericentral cells 4, around a much smaller central cell, ecorticate, with segments in median parts of main branches 400–500 μ in diameter and 0.5–0.6 diameter long with relatively thick walls; trichoblasts one per segment in $\frac{1}{4}$ spiral sequence, with 3–4 dichotomies, mostly short but sometimes to 560 μ long and about 18 μ in diameter at the base and tapering to very delicate tips, often more or less persistent; all or nearly all fruiting branches cicatrigenous in origin, relatively short and prominently narrowed at the base; tetrasporangia to 80 μ in diameter, in spiral series but not protuberant; cystocarps 270–320 μ in diameter, slightly urceolate, with cells of the ostiolar rim not enlarged; spermatangial branches 200–240 \times 45–60 μ , usually with a sterile tip composed of 1–2 short cells, arising as a primary fork of a trichoblast.

TYPE LOCALITY: Isla Grande, Guerrero, Mexico.

MATERIAL STUDIED: HAWAIIAN ISLANDS—D. 19145AM1, D. 19116B1, D. 19116Q2, D. 19116R2, on other algae all dredged 20 fa, Pokai Bay, Oahu, Sept. 15, 1959; D. 19125C2, tetrasporic, cystocarpic, and spermatangial, on *Amphiroa* sp., D. 19125L1, on *Spyridia*, dredged 13 fa, Pokai Bay, Oahu, July 29, 1959; PHILIPPINE ISLANDS—two collections by D. P. Abbott, one tetrasporic, on other algae, northeast coast of Siasi I., Sulu Sea, Jan. 28, 1957; and the other tetrasporic, spermatangial, on *Udotea* sp., Faganak I., Turtle Group, Feb. 24, 1957.

The central and western Pacific specimens differ from the type in having trichoblasts regularly one per segment, in the lack of a creeping base, and in having much larger main axes. They agree with Mexican specimens in most other respects. In the original description of *P. beaudettii* the branches were described as

“seemingly arising in connection with trichoblasts.” They definitely do not arise in connection with trichoblasts in the case of the central and western Pacific specimens. Further collections will be needed to determine these points and to determine the correctness of the disposition of the specimens reported here.

Polysiphonia delicatula sp. nov.

Fig. 1F

Minute epiphytic algae, chiefly prostrate, with creeping branches 40–50–(80) μ in diameter with walls 5–6–(8) μ thick, composed of segments mostly 1.0–1.5 diameters long and attached at frequent intervals by unicellular rhizoids, which are cut off as separate cells from the center of the pericentral cells; with very short, terminal trichoblasts, one per segment, which are quickly deciduous; erect branches distinctly smaller to 2.5 mm high, with segments in median parts mostly 25–30 μ in diameter, and 1.0–1.4 diameters long, arising cicatrigenously at distant intervals; lateral branches rare, arising in place of trichoblasts; pericentral cells 4, ecorticate; trichoblasts mostly very delicate, short and quickly deciduous, but occasionally persisting and up to 230 μ long, with 2–4 semidichotomous branches and with a basal cell 6–7–(15) μ in diameter and 8–12 diameters long; trichoblasts mostly one per segment in $\frac{1}{4}$ spiral sequence near branch tips; scar-cells about 6 μ in diameter in corresponding positions on both prostrate and erect branches but often many consecutive segments with no scar-cells; tetrasporangia 25–30–(50) μ in diameter in short spiral series of about 10 toward the apices of erect branches whose segments are greatly distended; procarps 2–4 per erect branch, cystocarps and spermatangial branches unknown.

Algae epiphyticae minutae, praecipue prostratae, per rhizoidea unicellularia, ut cellulas discretas separata, affixae; rami erecti ad 2.5 mm alt., raro ramosi, 25–30 μ diam., segmenta in partibus mediis 1.0–1.4 plo longiora quam lata habentes, in intervallis remotis cicatrigenone enascentes; cellulae pericentrales 4, ecorticatae; trichoblastae plerumque una in unoquoque segmento, delicatae, breves, cito deciduae; cellulae cicatrices ca. 6 μ diam, in ramis et erectis et prostratis, plerumque una in unoquoque segmento; tetrasporangia plerumque 25–30 μ diam, ca. 10 in serie brevi spirali, segmenta nultum distendentia; organa sexualia matura non observata.

TYPE: D. 19116G2, cystocarpic, on *Galaxaura* sp., dredged 15 fa, Pokai Bay, Oahu, Hawaii, Aug. 1, 1959. It is represented by a glucose microslide.

ADDITIONAL COLLECTIONS EXAMINED: HAWAIIAN ISLANDS—D. 19144AX2, on other algae, dredged from 5–12 fa, Port Allen, Kauai, Sept. 12, 1959; D. 10821C, on a small boat just below the waterline, Kaneohe Bay, Oahu, Oct. 7, 1953; D. 19135Z4, tetrasporic, dredged from 26 fa, in front of the river, Waialua, Oahu, Aug. 2, 1959; TUAMOTU ARCHIPELAGO—D. 11514B, on *Liagora* sp. at a depth of 3–4 ft in channels, south of Oneroa, and D. 11857.31, on dead coral near Otetou, Raroia Atoll, legit M. S. Doty and Jan Newhouse, Aug. 5, 1952; MARSHALL ISLANDS—D. 9456B, tetrasporic, on the under side of a coral head, Arno Atoll, Aug. 10, 1951; H. 48–1091.1, on *Halimeda* sp., outer reef, Arji I., Bikini Atoll, July 12, 1948; H. 48–1609C, tetrasporic, on *Microdictyon*, several miles north of Bikini I., Bikini Atoll, July 5, 1948; H. 48–1213.7, Amen I., Bikini Atoll, July 7, 1948; CAROLINE ISLANDS—D. 23032.5, on *Microdictyon* sp. on the reef between Ifaluk and Falalap islands, legit E. Menez, Aug. 10, 1960.

This species resembles *P. anomala*, which see for distinctive features. It also resembles *P. tuberosa*, from which it differs in having mostly unbranched erect branches. It lacks the tuberous food-filled rhizome frequently present in *P. tuberosa*. From *P. tenuis* it differs in being much more slender with much more reduced trichoblasts and considerably smaller scar-cells. As many as 90 segments occur in the erect branches of D. 11857.31 beyond a lateral branch.

Polysiphonia flaccidissima Hollenberg

Plants to 3 cm high from limited prostrate branches, attached by unicellular rhizoids cut

off as separate cells from the proximal end of the pericentral cells; erect branches mostly less than 150 μ in diameter and with segments mostly 1.5–2.0 diameters long; lateral branches mostly at intervals of 6–10 segments, arising in association with trichoblasts; pericentral cells 4, ecorticate; trichoblasts delicate, unbranched or with 1–2 dichotomies, one per segment in $\frac{1}{4}$ spiral series, tetrasporangia one per segment in slightly spiral series somewhat distending the segments; cystocarps globular; spermatangial branches arising from a primary fork of a trichoblast, with or without a sterile tip.

TYPE LOCALITY: Laguna Beach, Orange County, California. This species, originally described (Hollenberg, 1942b: 783) from southern California, is a variable species of very wide distribution.

P. flaccidissima var. *flaccidissima* Hollenberg (1942b:784)

Figs. 2A, 11

Plants 1–3 cm high with limited prostrate portions; median parts of erect branches 100–110–(170) μ in diameter and 1.0–1.5–(2.5) diameters long; walls thin and hyaline; main axes relatively distinct with laterals more or less distichous, arising mostly at intervals of 6 segments but often at intervals of 10 or more segments; branches slightly narrowed at the base; trichoblasts associated with branches unbranched or with 1–3 branches and up to 365 μ long; scar-cells on both erect and prostrate branches; reproductive structures characteristic of the species, but the spermatangial branches generally lacking a sterile tip.

TYPE LOCALITY: Orange County, California.

COLLECTIONS IDENTIFIED: HAWAIIAN ISLANDS—D. 19144T1, epiphytic, Port Allen, Kauai, dredged 5–13 fa, Sept. 12, 1959; M. 737, (as

KEY TO THE VARIETIES OF *Polysiphonia flaccidissima*

1. Erect branches mostly less than 1 cm high and less than 70 μ in diameter 2
1. Erect branches mostly over 1 cm high and more than 70 μ in diameter var. *flaccidissima*
2. Lateral branches infrequent var. *lopi*
2. Lateral branches at intervals of 4–10 segments 3
3. Lateral branches mostly at intervals of 10 segments, prostrate branches well developed ... var. *decimera*
3. Lateral branches mostly at intervals of 4–6 segments, prostrate branches absent or poorly developed var. *iki*

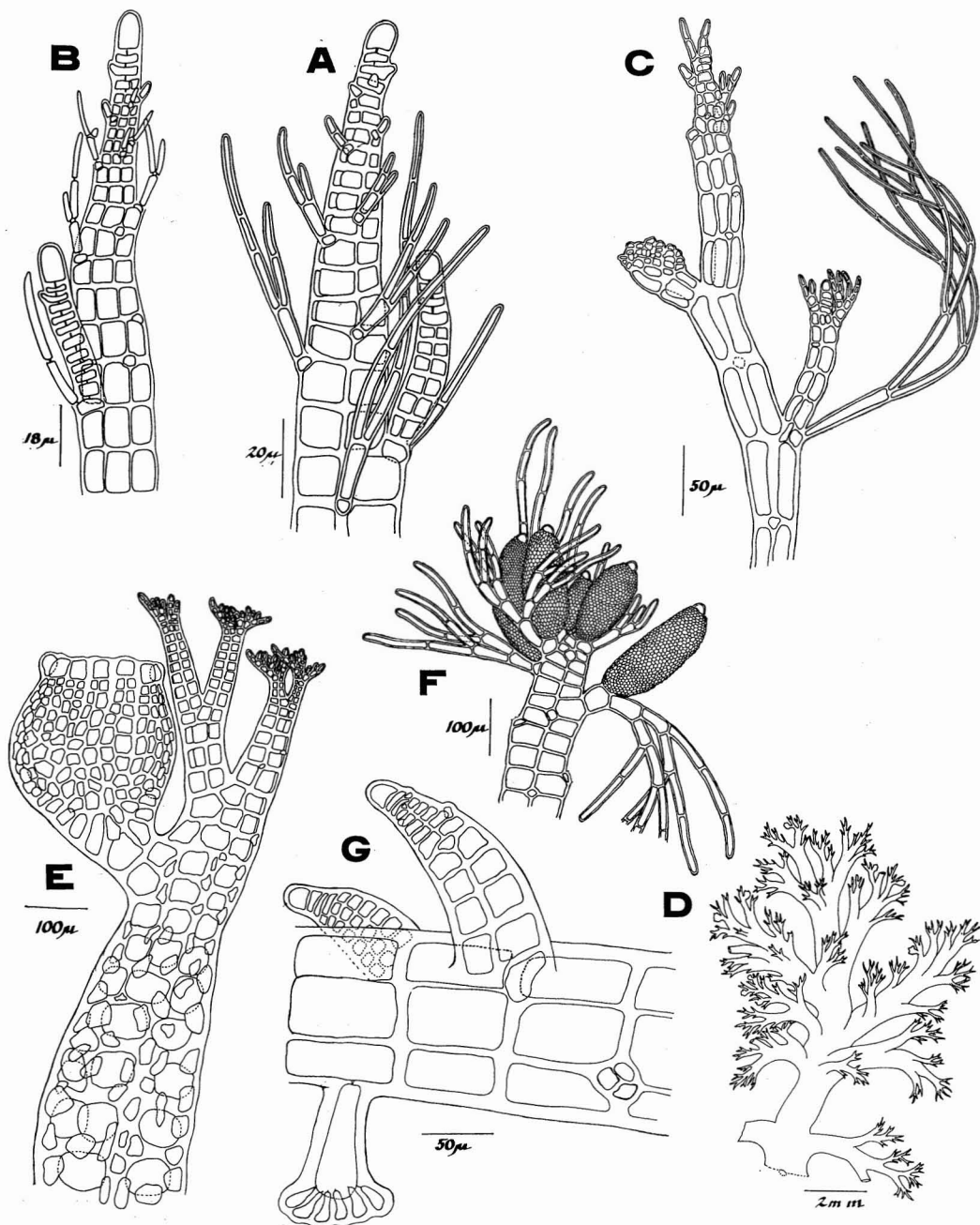


FIG. 2. A, *Polysiphonia flaccidissima* var. *flaccidissima*, branch apex. B, *Polysiphonia flaccidissima* var. *lopi*, branch apex. C, *Polysiphonia flaccidissima* var. *iki*, branch apex with young lateral branch and young cystocarp. D, *Polysiphonia hancockii*, habit sketch. E, *Polysiphonia hancockii*, branch with cystocarp. F, *Polysiphonia hawaiiensis*, branch apex with spermatangial stichidia. G, *Polysiphonia heipa*, prostrate branch with rhizoid showing multicellular apex.

P. mollis) on *Rhizophora* roots, Coconut Island Laboratory, Kaneohe Bay, Oahu, June 22, 1961; D. 19885.2–19886, abundant on rocks east of Kolo wharf, Punakou, Molokai, Dec. 31, 1953; PHOENIX ISLANDS—Degener 24867a, tetrasporic, Canton I., date?; MARSHALL ISLANDS—Da. 12683, 12729, Uliga I., Mariuro Atoll, Oct. 12, 1954; H. 48–1213.26, on *Pocockiella*, Bikini I., Bikini Atoll, July 7, 1948; H. 48–Y44.1, on *Microdictyon*, Bogen I., Eniwetok Atoll, July 25, 1948; H. 48–Y71, on *Microdictyon*, Runit I., Eniwetok Atoll, July 27, 1948.

P. flaccidissima var. *decimera* var. nov.¹

Fig. 12

Minute algae, to barely 2 mm high from creeping branches to 55 μ in diameter and with segments one diameter long or mostly shorter; erect branches similar with lateral branches commonly at intervals of 10 segments; trichoblasts 400–500 μ long with 3–5 dichotomies, tapering to delicate apices, scar-cells large (to 10 μ in diameter).

Algae minutae, usque ad vix 2 mm alt., e ramis repentibus ad 55 μ diam., segmentis aequae longis ac latis aut plerumque brevioribus, enascentes; rami erecti repentibus similes, ramos laterales intervallis 10 segmentorum plerumque habentes; trichoblastae 400–500 μ long., 3–5 dichotomias habentes, ad apices delicatos attenuatae; cellulae-cicatrices magnae (ad 10 μ diam.).

TYPE: H. 65–82, sterile, growing on dead coral at a depth of 1–2 m, 20 m shoreward from the outer reef margin, north of North I., Johnston I., legit R. S. Jones, Apr. 22, 1965.

One additional collection, H. 65–85.1, on *Pocockiella*, Diamond Head Beach, Oahu, Hawaii, was made by Mitsuo Kajimura, May 4, 1965.

The diminutive size and the strong tendency for branches to arise at intervals of 10 segments are the distinctive features.

P. flaccidissima var. *iki* var. nov.

Figs. 1G, 2C

Minute, epiphytic algae, mostly less than 1 cm high, from a basal attachment with little or no prostrate portion; main branches 50–75 μ in diameter; lateral branches few, at intervals of 4–6–(12) segments; scar-cells small but often pigmented; tetrasporangia 40–50 μ in

diameter, in short, slightly spiral series; spermatangial branches 116–190 μ \times 36–40 μ with a short sterile tip of 1–2 cells; cystocarps seen were immature.

Algae minutae, epiphyticae, plerumque breviores quam 1 cm, ex affixione basali enascentes, parte prostrata minima vel nulla; rami principales 50–75 μ diam.; rami laterales intervallis 4–6–(12) segmentorum enascentes; cellulae-cicatrices parvae, saepe, autem, coloratae; tetrasporangia 40–50 μ diam., in serie brevi paululum spirali; rami spermatangiales 116–190 μ \times 36–40 μ , cacumen breve sterile ex 1–2 cellulis compositum habentes; cystocarpi visi immaturi.

TYPE: D. 19145M1, tetrasporic, dredged 6–14 fa, Port Allen, Kauai, Hawaii, Sept. 12, 1959, is represented by a glucose mount. Additional material studied, all from the Hawaiian Islands: D. 19118C2, cystocarpic, on *Sargassum* sp., dredged 16–25 fa, Pokai Bay, Oahu, Aug. 1, 1959; D. 19144J1 and 19144Q1, spermatangial, on *Liagora* sp., dredged 6–14 fa, along with the type.

This variety is named for its minute size (*iki* is the Hawaiian word for tiny). Otherwise it has the features of the species.

P. flaccidissima var. *lopi* var. nov.

Figs. 1H, 2B

To 7.5 mm high from prostrate branches 40–50 μ in diameter; erect branches 30–45–(60) μ in diameter, of segments mostly 2 diameters long or longer, sparsely branched with 10–20–(30) segments between successive branches, which are gradually narrowed at the base; trichoblasts mostly short with 1 dichotomy, occasionally to 275 μ long composed of 3–4 very long cells 3.5–4.0 μ in diameter and relatively uniform in diameter throughout their length; mature reproductive structures not observed.

Plantae ad 7.5 mm alt., e ramis prostratis 40–50 μ diam. enascentes; rami erecti 30–45 μ diam. constantes e segmentis plerumque 2 plo longioribus vel plus quam lata, sparse ramosi, 10–20–(30) segmentis inter ramos successivos, ad basim gradatim angustatos; trichoblastae plerumque breves, unam dichotomiam habentes, interdum ad 275 μ long., e 3–4 cellulis longissimis 3.5–4.0 μ diam. compositae, relative uniformes diametro per longitudinem; structurae reproductivae maturae non observatae.

TYPE: D. 10821, tetrasporic, cystocarpic, on a boat, just below the water line, Kaneohe Bay,

Oahu, Oct. 7, 1953. The cystocarps are immature.

ADDITIONAL COLLECTIONS: Da. 19539, reef north of Sand I., Palmyra Atoll, Line Islands, Oct. 18, 1958; G. 524.1, sterile, as a delicate thin fuzz over a dead coral branch in the lagoon at a depth of about 28 m, Eniwetok Atoll, Marshall Islands, Aug. 30, 1955 (the trichoblasts subtending the branches unbranched in these specimens); G. 592.1, sterile, from a depth of 8 fa in the lagoon at Eniwetok Atoll, of the Marshall Islands, Sept. 2, 1955.

This variety is characterized by its small and delicate nature and by the distantly placed lateral branches. *Lopi* is the Hawaiian word for thread.

Polysiphonia hancockii Dawson (1944:331)

Figs. 2D, 2E, 13, 14

Epiphytic algae to 1.5 cm high with main axes to 900 μ in diameter, attached basally by numerous rhizoids; median parts of main axes 500–600 μ in diameter, with segments $\frac{1}{4}$ – $\frac{1}{3}$ diameters long; pericentral cells 4, sparsely to completely but thinly corticated at the base of main axes and often slightly corticated in the major laterals; main axes mostly prominent, with somewhat distichous laterals of limited growth, but branching sometimes deliquescent (Fig. 2D); trichoblasts one per segment in $\frac{1}{4}$ spiral sequence, mostly short, with 2–3 dichotomies, but occasionally to 700 μ long with 5–6 dichotomies, soon deciduous; scar-cells inconspicuous; branches arising independent of trichoblasts mostly at intervals of 6 segments; tetrasporangia to 70 μ in diameter, spirally arranged and protuberant, in repeatedly pseudo-dichotomous laterals; cystocarps globular to slightly urceolate, 280–400 μ in diameter, with prominently enlarged cells of the ostiolar rim; spermatangial stichidia lanceolate, to 200 μ \times 45 μ , without a sterile tip, arising as a primary branch of a trichoblast.

TYPE LOCALITY: San Jose del Cabo, Lower California, Mexico.

COLLECTIONS IDENTIFIED (all from the Hawaiian Islands): D. 17400, spermatangial, Laie Pt., Oahu, Mar. 17, 1959; D. 19853C, tetrasporic, cystocarpic, spermatangial, near low tide level on rocks near the mouth of Halawa stream,

Molokai, in water fresh to taste, Dec. 26, 1953; D. 20047.2, on wave-battered volcanic rock, Laie Pt., Oahu, legit R. Tsuda, R. Buggeln, and Gavino Trono, May 5, 1963; D. 22400, tetrasporic, D. 22401.1, tetrasporic, and D. 22410.1, tetrasporic, in intertidal algal turf, Papawai Pt., southwest of Maalaea Bay, Maui, legit H., T., and B., Apr. 19, 1965; D. 17184AC, D. 22534, cystocarpic, in algal turf, near Honokohau, Maui, legit H., T., and B., Apr. 20, 1965; D. 17197A11, Kalapana Beach, Kaimua Bay, Island of Hawaii, Feb. 27, 1953; D. 17333.1 on *Corallina* sp. $\frac{1}{4}$ mile southwest of Opihikao, Puna, Island of Hawaii, Jan. 27, 1953; also a collection by C. M. Cook, Jr., cystocarpic, on *Gelidium* sp., Island of Hawaii, June 21, 1935.

Polysiphonia hawaiiensis sp. nov.

P. ferulacea Menez (1964:209); *P. ferulacea* Segi(?) (1951:209); non *P. ferulacea* Suhringar ex J. G. Agardh (1863:980)
Figs. 2F, 16, 41

Plants dull reddish brown, chiefly epiphytic, densely tufted, rigid 4.5–5.0 cm high from a limited prostrate base, attached by frequent unicellular rhizoids cut off by a cross-wall from the proximal end of the pericentral cells, occasionally with a discoid base composed of a tuft of rhizoids; rhizoids commonly with digitate tips; main erect axes mostly 300–500 μ in diameter, composed of 4 ecarticate pericentral cells and of segments mostly 0.5–1.0 diameter long, with the cells not tumid but having mostly straight outer walls; branches replacing trichoblasts, at first strongly curved toward the parent branch, but later oriented at a wide angle somewhat less than a right angle, little or not at all narrowed at the base; trichoblasts one per segment in $\frac{1}{4}$ spiral sequence, mostly short and soon deciduous but sometimes well developed to 500 μ long with about 4 dichotomies, with apices not much tapered, 8–10 μ in diameter at the tips, up to 40 μ at the base, and with the short basal cell 1–1.5 diameters long; scar-cells small; mature tetrasporangia 60–90 μ in diameter, prominently spiralling in the ultimate branches which are not much distended; cystocarps globular, mostly 300–400 μ in diameter, with cells of the ostiolar rim not much enlarged, spermatangial branches oblong-ovoid, arising

as a primary branch of a trichoblast, 200–250 μ \times 80–100 μ with a relatively inconspicuous sterile tip consisting mostly of one small cell with a relatively thin wall.

Plantae praecipue epiphyticae, conferte fruticulosae, ad 5 cm alt., e basi prostrata praefinita, per rhizoidea unicellularia, ut cellulas discretas separata, affixa; axes principales erecti 300–400 μ diam.; cellulae pericentrales 4, ecorticatae; segmenta partibus in mediis ramorum erectorum 0.5–1.0 plo breviora quam lata; rami pro trichoblastis substituti, postremo late divergentes; sine axibus percurrentibus; trichoblastae una in unoquoque segmento, in $\frac{1}{4}$ spira, plerumque breves et mox deciduae; tetrasporangia in ramis ultimis spiraliter ordinata; cystocarpia globosi; 300–400 μ diam.; rami spermatangiales oblongo-ovoidei, cacumen parvum unicellulare sterile, ut ramum trichoblastae primarium enascens, habentes.

TYPE: D. 18764, tetrasporic, cystocarpic, spermatangial, epiphytic on a species of *Sargassum* from shallow water, Sans Souci Beach Laboratory, Waikiki Beach, Oahu, Hawaiian Islands, legit G. J. Hollenberg, Jan. 21, 1963. The species is very abundant at this locality.

ADDITIONAL COLLECTIONS: HAWAIIAN ISLANDS—D. 8755, spermatangial on *Sargassum* sp., D. 8756, spermatangial, Ala Moana Park, Honolulu, Oahu, Mar. 19, 1951; D. 10999, cystocarpic, spermatangial, awash, Laie, Oahu, Jan. 17, 1954; D. 17373, cystocarpic, near Natatorium, Waikiki Beach, Oahu, Nov. 20, 1955; H. 62–11, spermatangial, on other algae, cast ashore, Sans Souci Beach Laboratory, Waikiki Beach, Oahu, Dec. 12, 1962; H. 65–14, spermatangial, dredged 2–3 fathoms, Kaneohe Bay, Oahu, Mar. 20, 1965; an unnumbered collection by Isabella Abbott, on *Laurencia* sp., Makahoa Pt., Oahu, Mar. 17, 1941; M. 713B, tetrasporic, on *Acanthophora* sp., on reef flat, Waikiki Beach, Oahu, Feb. 24, 1961; D. 13005, outer side of breakwater, Maalaea, Maui, Aug. 27, 1955; D. 19067.1, cystocarpic, spermatangial, Kaanapali Landing, Maui, Mar. 22, 1959; D. 19079, spermatangial, near St. Theresa Church, Kihei, Maui, Mar. 22, 1959; D. 22348, tetrasporic, spermatangial, on other algae, intertidal basalt, east of Maalaea, Maui, legit H., T., and B., Apr. 19, 1965; D. 22367, tetrasporic, cystocarpic, spermatangial, Maalaea, Maui, H., T., and B., Apr. 19, 1965; D. 22473, tetrasporic, spermatangial on reef flats north of Honokowai, Maui, legit H., T., and B., Apr. 20, 1965;

D. 22525.1, spermatangial, on *Sargassum* sp., in shallow water, northern Maui, legit H., T., and B., Apr. 20, 1965; SOCIETY ISLANDS—D. 12114.6, Arue Pt., Arue District, Tahiti, Sept. 15, 1952; PHILIPPINE ISLANDS—Certain specimens mostly considerably smaller than the Hawaiian specimens have been identified with some misgivings as *P. hawaiiensis*: a collection by D. P. Abbott, on and among tufted algae, Gnat Reef, Balabac I., Sulu Sea, Mar. 2, 1957, seems close to *P. sparsa* in size and length of segments; an epiphyte collected by D. P. Abbott, Tijiitiji reef, Tawitawi, Sulu Sea, Feb. 15, 1957.

Also referred to this species with some hesitation are the following: D. 14697, tetrasporic, on *Sargassum* sp. Labrador, Tandjang, Berlayar, Singapore, Jan. 25, 1965; W. H. Harvey, Alg. Ceylon No. 12, cystocarpic, spermatangial (as *P. binneyi* Harv.) on other algae, Rijksherbarium (Herb. Lugd. Bat. No. 941, 182–83). These two plants are smaller and more slender than the Hawaiian specimens and the trichoblasts are poorly developed.

A specimen identified as *P. ferulacea* f. *implicata* Tseng (1944:76) may prove to be a variation of *P. hawaiiensis*. Tseng does not indicate the height of his plant and efforts to obtain a loan of his Hong Kong specimens have met with no success.

Numerous herbarium specimens of this taxon, mostly from Oahu, are to be found in the Bishop Museum, Honolulu. Many of these have been annotated by E. G. Menez (1964) as *P. ferulacea*.

This alga has been commonly identified as *P. ferulacea* J. G. Agardh, which it resembles in a number of respects. From that species it differs chiefly in the widely divaricate branching, with percurrent axes, when present, lost in the terminal parts. Taylor (1960) describes the branching of *P. ferulacea* as "subfastigate to virgate above." In a communication from Dr. Sven Snogerup, Keeper of the Botanical Museum at Lund, Sweden, he mentions mounted specimens of *P. ferulacea* on sheets signed by J. G. Agardh. Two specimens, 40176 and 40181, are from "Vera Cruz, Liebmann," and in addition there are two specimens, 40178 and 40179 "from Guadaloupe, coll. Duchchassaing" accompanied by a mica preparation, 40180, "apparently from a cut-off part of one of them."

These specimens are labeled *P. ferulacea* "in J. G.'s handwriting, followed by a mark of exclamation," leading Dr. Snogerup to conclude that they must perhaps be regarded as the type collection. Photographs of these specimens sent by Dr. Snogerup and one loose duplicate (40186) of "Vera Cruz Liebmann" represent plants with prominent leading axes especially in the upper parts, very unlike the divaricately branched Hawaiian specimens.

If one accepts the view of Boergesen (1918:277) that *P. breviaritculata* Harvey is to be identified with *P. ferulacea* J. G. Agardh, the figures of the former given by Harvey (1853: Tab. XVII) represent a plant with strictly erect habit, with distinct percurrent axes and alternate branching, forming a penicillate tuft very unlike the Hawaiian plant. Furthermore, Boergesen gives the impression that the specimens he identified as *P. ferulacea* are saxicolous, forming "together with *Caulerpa* . . . and other algae, low compact patches." The Hawaiian plants always seem to be epiphytic.

Finally, judging by descriptions and figure by Boergesen (1918:280, fig. 279) of the spermatangial branches of plants he identified as *P. ferulacea*, and also by spermatangial branches of various specimens from Florida and elsewhere in the southeastern United States, the writer is led to the conclusion that the male reproductive structures of the Hawaiian plants are short and stout (Fig. 2F) as are those of *P. ferulacea*, but differ from the latter in several respects: (1) they are considerably larger and more ovoid in form, rather than cylindrical; (2) there are fewer at a given branch tip, usually 2-3 present at any given time; (3) the sterile tip is much smaller, is neither globular nor thick-walled, and does not consist of two cells as is the case in *P. ferulacea* as figured by Boergesen.

Polysiphonia herpa sp. nov.

Lophosiphonia bermudensis Dawson, 1956: 59, fig. 65; non *Lophosiphonia bermudensis* Collins and Hervey (1917:126), which is *Dipterosiphonia rigens* (Schousb.) Falk. Figs. 1I, 2G

Chiefly prostrate algae, with the prostrate branches mostly 100-140 μ in diameter and with

segments 0.6-1.0 diameter long, attached by rhizoids which are cut off by a cross-wall from the proximal end or center of the pericentral cells and which commonly have multicellular discoid tips; erect branches to 3 mm high and 90 μ in diameter, with segments mostly about 0.5 diameter long, arising cicatrigenously, commonly at intervals of 4 segments and frequently in alternating pairs, one on either side of the prostrate branch, with one segment between members of a pair and 4 segments between corresponding members of successive pairs; erect branches with short segments, mostly unbranched or with one or two erect laterals from near the base; young branches at first strongly arched toward the prostrate branch; pericentral cells 4, ecorticate; trichoblasts on erect branches one per segment in $\frac{1}{4}$ spiral sequence, mostly not well developed but occasionally to 1.3 mm and with 4-5 dichotomies, quickly deciduous, leaving relatively large scar-cells and commonly prominent wall scars at the point of abscission; trichoblasts on prostrate branches represented by exogenous primordia ("scar cells") only, most of which divide to form 3 or 4 small cells (branch primordia), from which the cicatrigenous branches later arise; reproductive structures not observed.

Algae praecipue prostratae, ramis prostratis plerumque 100-140 μ diam., segmentis plerumque brevioribus quam lata, per rhizoidea, a cellulis pericentralibus per dissepimentum separata, et cacumina multicellularia vulgo habentia, affixae; rami erecti ad 3 mm alt. et 90 μ diam., segmentis plerumque ca. 0.5 plo breviores quam lata, vulgo non ramosis, intervallis 4 segmentorum cicatrigenose et plerumque binatim enascentibus; cellulae pericentrales 4, ecorticae; trichoblastae in ramis erectis, una in unoquoque segmento, in $\frac{1}{4}$ spira, mox deciduae; cellulae-cicatriceae relative magnae, eae in cellulis prostratis ad cellulas parvas ternas quaternasve formandas plerumque divisa; structurae reproductivae non observatae.

TYPE: D. 11857.2, abundant in tufts on dead coral on the sea reef near Otetou, Raroia Atoll, Tuamotu Archipelago, legit M. S. Doty and Jan Newhouse, Aug. 21, 1952. It is represented by glucose microslide mounts and abundant fluid-preserved material.

ADDITIONAL COLLECTIONS: HAWAIIAN ISLANDS—D. 19643DA, on a mollusc shell, dredged 8-10 fa, east side of Barber's Point,

off Ewa Beach, Oahu, Feb. 22, 1962; D. 19143R1, on other algae, dredged 31–32 fathoms, Penguin Bank, southwest of Molokai, Sept. 7, 1959; LINE ISLANDS—D. 20041, on mollusc shell, seaward reef flat, Christmas I., legit Ralph E. Palumbo, May 16, 1962; TUAMOTU ARCHIPELAGO—D. 11189.3, on dead coral, D. 11857.6, D. 11858.2, D. 11860C, all from lagoon transect, Otetou, Raroia Atoll, legit M. S. Doty and Jan Newhouse, Aug. 21, 1952; MARSHALL ISLANDS—D. 9586A, rock scrapings, D. 9599E, on *Udotea* sp., D. 9599GA, on *Laurencia* sp., D. 9693B, on *Halimeda* sp., all on lagoon reef off Ine Village, Ine I., Arno Atoll, legit Leonard Horwitz, Aug. 17, 1951; H. 48–0914.15, on *Microdictyon* sp.; H. 48–0914.22, on *Dictyosphaeria* sp., H. 48–1091.13, on *Pocockiella*, outer reef, Arji I., Bikini Atoll, July 12, 1948 (probably all of these should be identified with this species although in some the segments are frequently more than one diameter long in both prostrate and erect branches, and rhizoids arise mostly at the proximal end of the pericentral cells); CAROLINE ISLANDS—D. 15989.3, on other algae, Helen Reef area, legit E. Menez, Aug. 28, 1960.

D. 11858.2 from sea reef near Otetou, Raroia Atoll, Tuamotu Archipelago, represents a variation in which the erect branches are up to 7 mm high with more laterals and with segments about 1 diameter long. A variant, H. 48–1091.13 from the outer reef of Arji I., Bikini Atoll, in the Marshall Islands has prostrate branches only 90 μ in diameter and segments to 1.6 diameters long.

Polysiphonia mollis Hooker and Harvey

For synonymy see Hollenberg (1961:359), also *P. aquamara* Abbott (1947:212).

Fig. 43

Plants to 8 cm high, assurgent from limited prostrate portions attached by unicellular rhizoids, with or without lobed tips, cut off mostly from the proximal end of the pericentral cells by a cross-wall; 4 pericentral cells, ecorticate, with segments 1.5–3.0 diameters long in the main branches and with segments somewhat nodose at the ends; median parts of erect branches 120–180 μ in diameter; branching pseudodichotomous and corymbose, with

branches of many orders arising exogenously in place of, and not in connection with, trichoblasts, with mostly 6–8 segments between successive branches; branches gradually narrowed toward the base; trichoblasts one per segment in regular $\frac{1}{4}$ spiral sequence, commonly 100–280 μ long with 1–3 forks, but often poorly developed, soon deciduous, leaving scar-cells of moderate size; basal cell commonly considerably shorter than cells next above; tetrasporangia 60–80 μ in diameter in slightly or prominently spiral series in the ultimate ramuli; cystocarps ovoid to globular up to 300 μ in diameter; spermatangial branches measuring 140–270 μ \times 60–75 μ , arising mostly as a primary fork of a trichoblast but sometimes as a secondary fork and sometimes bearing a short or longer sterile tip of 2–4 cells.

Mostly plants of relatively quiet water, and often of brackish water.

TYPE LOCALITY: Tasmania.

COLLECTIONS STUDIED: HAWAIIAN ISLANDS—D. 9765B, tetrasporic, cystocarpic, Sand I., Honolulu, Oahu, Jan. 27, 1956; D. 12386, 12389, from a pond-connecting channel, Coconut I., Oahu, Feb. 5, 1954; D. 12684, D. 12689, tetrasporic, cystocarpic, spermatangial, Keehi Lagoon, airport side of Mokuaea I., Oahu, Dec. 30, 1954; D. 12792, mudflats in front of Kuliouou Beach Park, Oahu, June 10, 1955; D. 13356, on Natatorium floats, Waikiki, Oahu, Oct. 2, 1956; M. 704, tetrasporic, on *Acanthophora*, near old sugar mill, windward Oahu, July 7, 1961; M. 725, 739, tetrasporic, on concrete blocks under and near a seaward bridge, Ala Moana Park, Oahu, May 5, 1961; M. 758, 759, tetrasporic, cystocarpic, muddy area at Keehi Lagoon, Oahu, Feb. 27, 1961; I. Abbott 1535, tetrasporic, cystocarpic and spermatangial, as *P. aquamara*, legit C. J. Engard, Kuapa Pond, Oahu, Apr. 7, 1944; I. Abbott, as *Polysiphonia aquamara* spermatangial, "Salt Lake," Oahu, July 2, 1945; TAHITI—Setchell 5213 (C. 261338), as *P. tongatensis* Harvey, legit W. A. Setchell and H. E. Parks, Port Phaeton, June 24, 1922; PHILIPPINE ISLANDS—a collection by D. P. Abbott, Siasi I., Jan. 28, 1957, a smaller and more slender form probably to be identified as *P. mollis* var. *tongatensis* (Harvey) comb. nov., is frequently found in sheltered

water along with the typical form of the species. Also representative of this variety is *H.* 65-79.5 (D. 22567) from muddy bottom in shallow water of an ancient fish trap, southeast Molokai, Apr. 22, 1965.

Polysiphonia poko sp. nov.

Fig. 3A

Plants to 4 mm high, assurgent from prostrate branches attached by unicellular rhizoids which are cut off from pericentral cells by a cross-wall, mostly from the proximal end; prostrate branches and larger erect branches 90-140-(190) μ in diameter; pericentral cells 4, ecorticate with segments mostly about 0.5 diameter long; erect branches mostly unbranched; all branches cicatrigenous, not narrowed at the base; trichoblasts not well developed or up to 500 μ or more long and 20 μ in diameter at the base with 3-4 dichotomies, arising one per segment in $\frac{1}{4}$ spiral sequence; scar-cells on prostrate and erect branches; wall-scars often prominent; tetrasporangia spirally arranged in the branches, slightly distending the segments; cystocarps globular-ovoid, to 360 μ in diameter with cells of the ostiolar rim not enlarged; spermatangial branches cylindrical, without a sterile tip; comprising a primary branch of a trichoblast.

Plantae ad 4 mm alt., assurgentes e ramis prostratis, per rhizoidea unicellularia, a cellulis pericentralibus per dissepimentum plerumque ab extremo proximali separata, affixis; rami prostrati et rami maiores erecti 90-140-(190) μ diam.; cellulae pericentrales 4, escorticatae, segmentis plerumque ca. 0.5 plo brevioribus quam lata; rami erecti vulgo non ramosi; omnis ramus cicatrigenus, ad basim non attenuatus; trichoblastae non bene evolutae aut usque ad 500 μ vel plus long. et 20 μ diam. ad basim. 3-4 dichotomias habentes, una in unoquoque segmento in $\frac{1}{4}$ spira nascente; cellulae cicatrices in ramis prostratis erectisque; membranae cicatrices saepe manifestae; tetrasporangia in ramis spiraliter ordinata, segmenta paululum distendentes; cystocarpi globoso-ovoides, ad 360 μ diam., cellulis orae ostioli non dilatatis; rami spermatangiales cylindrici, sine cacumine sterili, ramum primarium trichoblastae comprehendentes.

TYPE: *H.* 65-113.1, cystocarpic and spermatangial, on dead coral, at a depth of 1-2 m, 20 m shoreward from the outer reef margin, north of North I., Johnston I., legit R. S. Jones, Apr. 22, 1965.

The Hawaiian name, meaning short, refers

to the short segments. This species is close to *P. berpa*, from which it differs chiefly in the undivided scar-cells. It also lacks the multicellular tips of rhizoids common in *P. berpa*. It is in some respects similar to *P. sphaerocarpha*, differing in the mostly shorter segments in *P. poko* and in the unbranched erect branches of the latter.

This species also resembles *P. coacta* Tseng (1944), from which it differs in that: (1) the erect branches are mostly unbranched and seemingly exclusively cicatrigenous in *P. poko*, except for the assurgent origin of some of the erect branches from prostrate branches; (2) there is little or no evidence of coherence of erect branches by means of tentacular rhizoids as described for *P. coacta*.

P. poko var. *poko* var. nov.

Figs. 3A, 15

ADDITIONAL COLLECTIONS EXAMINED (those marked * are more slender, attenuate forms): HAWAIIAN ISLANDS—D. 10361.1, on other algae, Poipu Beach Park, Kauai, Feb. 6, 1952; D. 19710C, a poor specimen from the intertidal flow of the reef flat, Kumimi, Molokai, Dec. 29, 1953; D. 22410.2, a very delicate form, Papawai Point, Maui, legit H., T., and B., Apr. 19, 1965; JOHNSTON ISLAND—*H.* 65-106.7, spermatangial, on dead coral at the type locality, legit R. S. Jones, Apr. 22, 1965; LINE ISLANDS—*L.* 2720.3*, in crevices of reef flat, Jarvis I., Nov. 17, 1964; *L.* 2782.2*, on wave-swept reef near the airport, Christmas I., Nov. 23, 1964; TUAMOTU ARCHIPELAGO (all legit M. S. Doty and Jan Newhouse, 1952); D. 11518.1*, on *Microdictyon* sp., outer reef edge, Akau, Raroia Atoll, Aug. 5; D. 11160B3, on reef near ship pass, Takeke, Raroia Atoll, July 9; D. 11189.4, on other algae, lagoon transect, Ngarumaoa, Raroia Atoll, July 12; D. 11509.1*, on dead coral, near Pakokota, Oneroa, Raroia Atoll, Aug. 5; D. 11533.1, on *Caulerpa* sp. under coral overhang of reef in front of Oneroa Village, Raroia Atoll, Aug. 5; D. 11858.1*, on dead coral, sea reef near Otetou, Raroia Atoll, Aug. 21; PHOENIX ISLANDS—*L.* 2416.5, on *Halimeda* sp., western reef of McKean I., Oct. 18, 1964; *L.* 2444.4*, on *Halimeda* sp. in sandy pool, northeastern reef of McKean I., Oct. 20, 1964; *L.* 2451.10*, on

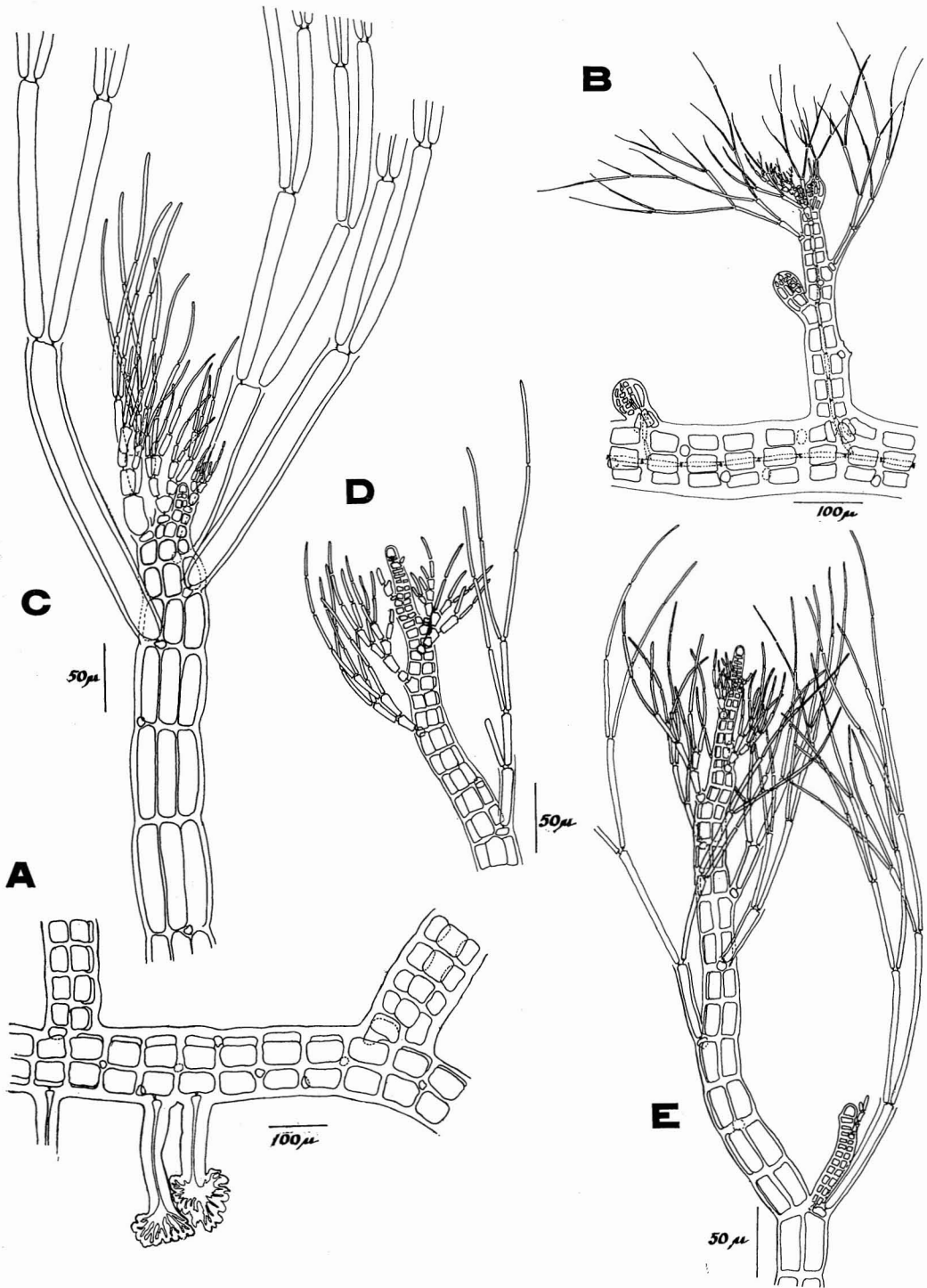


FIG. 3. *A*, *Polysiphonia poko*, prostrate branch and bases of erect branches. *B*, *Polysiphonia poko*, unnamed var., with young cystocarps and very delicate trichoblasts. *C*, *Polysiphonia pseudovillum*, apex of erect branch. *D*, *Polysiphonia tuberosa*, branch apex. *E*, *Polysiphonia tuberosa*, branch apex with delayed exogenous origin of a lateral in association with a trichoblast.

Halimeda sp., in surge channel, south reef of McKean I., Oct. 21, 1964; L. 2644.5*, on *Halimeda* sp., Birnie I., Nov. 8, 1964; L. 2659.1, in algal turf on intertidal rocks, northeast reef of Enderbury I., Nov. 9, 1964; MARSHALL ISLANDS—H. 48-0914.20, outer reef of Uku I., Bikini Atoll, July 9, 1948; H. 48-2894.5, Nama I., Bikini Atoll, July 15, 1948; H. 48-Y23, Japtan I., July 23, 1948; CAROLINE ISLANDS (all legit E. Menez, Aug., 1960)—D. 23032.2*, on *Microdictyon* sp., on reef between Ifaluk and Falalap islands, Aug. 10; D. 23056.1, on coral and other algae, on reef, northeast end of Puluwat I., Aug. 7; D. 23167.1 and D. 23207.1, among smaller algae, southern tip of Sorol I., Aug. 13; D. 23674.1, with other algae, western end of Puluwat I., Aug. 7.

A collection by A. J. Bernatowicz, 53-358, from Bailey's Bay, Bermuda, May 14, 1953, agrees in most details with the description given for this species, although the prostrate branches are somewhat more extensive and rhizoids have multicellular tips. No fruiting was observed in the Bermuda specimens.

A minute variant form of this species (Fig. 3B) is represented by H. 65-133 (Fig. 3B), cystocarpic, collected by R. S. Jones north of North I., Johnston I., Apr. 22, 1965. It is only 500 μ high with erect branches to 75 μ in diameter, with very delicate trichoblasts and with immature cystocarps on both erect and prostrate branches. No additional collections of this variant are available.

P. poko var. *longii* var. nov.

Fig. 22

With the general features of the species but relatively coarse, with erect branches to 1.3 cm high and commonly with 1-3 unilateral branches, and with the tips of erect branches frequently functioning as stolons and forming new prostrate branches; tetrasporangial branches to 3 mm long and 115 μ in diameter toward the base, mostly unbranched, and with 20-30 spirally arranged tetrasporangia, which are only slightly protuberant, and in some cases with evidence of at least as many tetrasporangia having been previously released from the lower segments.

Varietas propriales speciei generales praebens, plantae, autem, relative grossae, ramis erectis ad 1.3 cm alt., et vulgo 1-3 ramos unilaterales habentibus, necnon cacuminibus ramorum erectorum velut stolonibus saepe fungentibus et ramos prostratos novos formantibus; rami tetrasporangiales ad 3 mm long., et 115 μ diam. ad basim, magna ex parte non ramosi, 20-30 tetrasporangia spirally ordinata, vix protuberantia ferentes, signa indicantia quod saltem totidem sporangia e segmentis inferioribus paulo ante liberata.

TYPE: L. 2709.1, tetrasporic, from exposed coral heads near breaking waves on the southwest reef of Jarvis I., Line Islands, Nov. 16, 1964; glucose slide mounts and fluid preserved material.

ADDITIONAL COLLECTIONS: Two are identified with this species—L. 2703.1, tetrasporic, from exposed and protected parts of depressions and ridges on coral heads, near breaking waves, Jarvis I., Nov. 16, 1964; a collection by David Sigee No. 35 from Gan I., Addu Atoll, Maldive Islands in the Indian Ocean, July-Sept., 1964. One other collection is placed in this variety with some reservations, L. 2451.11, with matted algae, north shore of Gardiner I., Line Islands, Oct. 23, 1964. In this the segments of prostrate branches are as long or longer than broad (100 μ in diameter) and have rhizoids with multicellular tips.

Polysiphonia profunda sp. nov.

Figs. 18, 20

Minute, epiphytic algae with prostrate branches attached by unicellular rhizoids with digitate tips cut off from the proximal end of the pericentral cells or sometimes with a basal group of rhizoids and no prostrate branch; 4 ecorticate pericentral cells slightly flattened tangentially, with segments mostly less than one but occasionally 1.5-2.0 diameters long and with stratified walls to 15 μ thick and brownish in older parts; erect branches apparently of cicatrigenous origin; 125-145 μ in diameter and 4-6 mm long, with few lateral branches; lateral branches arising in connection with trichoblasts or cicatrigenously at intervals of 20-30 or more segments; trichoblasts very slender, to 400 (500) μ long and 8-12 μ in diameter at the base, with 3-4 forks, arising one per segment in $\frac{1}{4}$ spiral sequence, relatively persistent but when shed leaving small scar-cells 7-8 μ in

diameter; tetrasporangia 30–40 μ in diameter, in short series not much distending the segments; cystocarps globular, to 260 μ in diameter; spermatangial branches 175–200 μ \times 45–50 μ arising as a primary fork of a trichoblast, usually with 1–2 short cells forming a sterile tip.

Algae minutae, epiphyticae, ramos prostratos, affixos per rhizoidea unicellularia, cacuminibus digitatis praedita, ab extremo proximali cellularum pericentralium separata, interdum, autem, aggregationem rhizoideorum, ramo prostrato carente, habentes; 4 cellulae pericentrales excorticatae tangentialiter subcomplanatae, segmentis plerumque brevioribus quam lata, interdum, autem, 1.5–2.0 longiores quam lata, et parietes stratifectos, usque ad 15 μ crass. in partibus vetustioribus brunneolos, habentes; rami erecti, origine ut videtur cicatrigeni, 125–245 μ diam. 4–6 mm long., paucos ramos laterales habentes; rami laterales in associatione cum trichoblastis, aut cicatrigenae, intervallis 20–30 vel plurium segmentorum enascentes, trichoblastae tenuissimae ad 400 (500) μ long., 8–12 μ diam. ad basim, 3–4 furcas habentes, una in unoquoque segmento in spira enascente, relative persistentes, effusae, autem, cellulas-cicatrices parvas 7–8 μ diam. relinquentes; tetrasporangia 30–40 μ diam., in serie brevi, segmenta paulum distendentia; cystocarpi globosi, ad 260 μ diam., rami spermatangiales 175–200 μ \times 40–50 μ ut furca primaria trichoblastae enascentes, 1–2 cellulas breves, cacumen sterile formantes, plerumque habentes.

TYPE: D. 19116AI1, cystocarpic, attached to a species of *Galaxaura*, dredged from 15 fa, Pokai Bay, Oahu, Hawaii, Aug. 1, 1959. It is represented by a glucose microslide mount.

ADDITIONAL COLLECTIONS (all mostly sublittoral in habitat): D. 19116J2, spermatangial, on *Gracilaria* sp. dredged 15 fa, Pokai Bay, Oahu, Hawaii, Aug. 1, 1959; D. 19135L1, tetrasporic, cystocarpic, on *Sargassum* sp., D. 19135J2, on *Padina* sp., D. 19135W3, all dredged 26 fa, in front of the river, Waialua, Oahu, Hawaii, Aug. 2, 1959; D. 19143S1, spermatangial, on *Amansia* sp., dredged 15–20 fa, Ilio Pt., Molokai, Hawaii, Aug. 7, 1959.

This species is closest to *P. flaccidissima* in the origin of branches in relation to trichoblasts, and in its small size and delicate nature. From *P. flaccidissima* it differs in the relatively persistent trichoblasts, in the brownish color of the walls, and in the less frequent branches, terminal portions of erect branches having as many as 80 segments without a lateral branch.

Polysiphonia pseudovillum sp. nov.

Fig. 3C

Plants chiefly prostrate with creeping filaments to 60 μ in diameter, composed of segments 1.0–1.5 diameters long, attached by frequent unicellular rhizoids which are cut off from the proximal end of the pericentral cells by a cross-wall, and with a broad base in contact with the bearing cell although only a narrow pit-connection, and which may have digitate tips; erect branches arising cicatrigenously at frequent intervals, to 1 or up to 2.7 mm high and 40–60 μ in diameter, with segments about 1.5 diameters long, with slight constrictions at the nodes, and only occasionally with one or more laterals arising cicatrigenously in a pseudodichotomous manner; pericentral cells 4, ecorticate and with a central cell scarcely half the diameter of the pericentral cells; walls hyaline, 5–8 μ thick; trichoblasts to 1 mm long, with mostly 4 dichotomies and very slender tips, and with a basal cell to 350 μ long and 18 μ in diameter, arising at irregular intervals in part but mostly one per segment in $\frac{1}{4}$ spiral sequence in terminal parts of erect branches, tardily deciduous; scar-cells mostly one per segment on both prostrate and erect branches, but sometimes at intervals of two segments; tetrasporangia (immature) in short spiral series near the tips of branches; cystocarps ovoid to slightly urceolate, 150 μ broad and slightly longer than broad; spermatangial branches (only one seen) oblong, 220 μ \times 58 μ , arising probably as a primary branch of a trichoblast.

Plantae praecipue prostratae, filamenta repentia ad 60 μ diam., e segmentis 1–1.5 plo longioribus quam lata composita, affixa per rhizoidea unicellularia frequentia, per dissepimentum ab extremo proximali cellularum pericentralium separata, habentes; rami erecti intervallis frequentibus cicatrigenae enascentes, plerumque 1 mm alt. aut paululo altiores, segmentis ca. 1.5 plo longioribus quam lata, ramis inter segmenta aliquantulum constrictis, parvis ramis cicatrigenae enascentibus; cellulae pericentrales 4, ecorticatae, cellula centrali multo minore quam cellulae pericentrales; trichoblastae ad 1 mm long., ca. 4 dichotomias necnon cellulam basalem ad 350 μ long., 18 μ diam., una in unoquoque segmento in $\frac{1}{4}$ spira in partibus terminalibus ramorum erectorum maxima ex parte oriente, habentes. Cellulae-cicatrices plerumque una in unoquoque segmento in maris et erectis et prostratis, interdum intervallis 2 segmentorum; tetrasporangia in serie brevi spirali; cystocarpi aliquan-

tulum urceolati, ad 150μ lat. et paululo longiores; rami spermatangiales ut ramus primarius trichoblastae probabiliter enascentes.

TYPE: H. 65-52, tetrasporic, cystocarpic and spermatangial, growing on dead coral at a depth of 1-2 m, and 20 m shoreward from the outer reef margin, north of North I., Johnston I., legit R. S. Jones, Apr. 22, 1965. It is represented by fluid preserved material and 6-8 glucose microslide mounts.

ADDITIONAL COLLECTION: T. 1393, spermatangial, on top of a coral head at a depth of about 1 ft northeast of North I., Johnston I., Nov. 18, 1965.

The minute size and chiefly prostrate habit are features characteristic of *P. scopulorum* var. *villum*, but the rhizoids of *P. pseudovillum* are cut off as separate cells. Also the erect branches arise cicatrigenously in *P. pseudovillum* but endogenously in *P. scopulorum* var. *villum*.

Polysiphonia quadrata sp. nov.

P. coacta Tsuda (1964:11) not of Tseng (1944:71)
Fig. 25

Plants to 8 mm high, assurgent from creeping branches attached at frequent intervals by unicellular rhizoids which are cut off as separate cells from the proximal end of the pericentral cells and may have digitate tips; creeping branches $160-180\mu$ in diameter, composed of segments $0.3-0.5$ diameters long; assurgent erect branches $100-160\mu$ in diameter, with segments mostly about 0.5 diameter long and gradually very short near the tapering apices; branches infrequent, replacing trichoblasts; pericentral cells 4, ecorticate, mostly quadrate in external view, walls brownish and $8-10\mu$ thick in older parts; trichoblasts arising at irregular intervals of 4-8 or more segments, very rudimentary with 2-3 dichotomies, quickly deciduous, leaving relatively small scar-cells; reproductive structures unknown.

Plantae ad 8 mm alt., a ramis repentibus assurgentibus, affixae intervallis frequentibus per rhizoidea unicellularia quae ut cellulas discretas ab extremo proximali cellularum pericentralium separata et cacumina digitata interdum habent; rami repentibus $160-180\mu$ diam., e segmentis $0.3-0.5$ plo brevioribus quam lata compositi; rami erecti assurgentibus $100-160\mu$

diam., segmentis plerumque ca. 0.5 brevioribus quam lata necnon brevissimis prope apices attenuatos gradatim factis; rami infrequentes, pro trichoblastis substituti; cellulae pericentrales 4, ecorticatae, externe visae plerumque quadratae, parietes brunneolos, in partibus vetustioribus $8-10\mu$ crass. habentes; trichoblastae intervallis irregularibus 4-8 vel plurim segmentorum enascentes, multum elementariae, 2-3 dichotomias habentes, cito deciduae, cellulas-cicatrices relative parvas relinquentis; structurae reproductivae ignotae.

TYPE: D. 18774, collected by N. J. Cooper from below low water line on a reef just south of Rawanawi Village on the Marakei Atoll, Gilbert Islands, July, 1962.

ADDITIONAL COLLECTION: D. 18921.1, likewise sterile, was collected by the same person from the same general area, at a depth of 20-30 ft in a deep surge channel, July, 1962.

This species is very similar to a species with 5 pericentral cells to be described in Part II of this study. It differs, furthermore, in having mostly shorter segments in mature parts. The cells of *P. quadrata* plasmolyze readily in 20% glucose, due probably to the thinness of the walls of the relatively large pericentral cells of younger branches.

Polysiphonia rubrorhiza sp. nov.

Figs. 4A, 4B, 32

Epiphytic algae to 8 mm high initially attached by a tuft of rhizoids from a basal cell and adjacent pericentral cells, later attached by additional rhizoids arising from prostrate stolon-like branches of limited extent emerging from the basal segments of primary erect branches; rhizoids to 125μ long, enlarged saccate to 110μ in diameter, thin-walled, deeply pink with numerous peripheral chromatophores about 3μ in diameter, arising as separate cells cut off from the pericentral cells and penetrating among the utricles of the host; pericentral cells 4, ecorticate, with segments as long as broad or slightly longer; erect branches $75-100\mu$ in diameter in the median parts, either endogenous or cicatrigenous in origin, pseudodichotomously branched above at intervals of (2)-5-10 segments, the branches arising independent of the trichoblasts; trichoblasts to 680μ long, with 2-4 dichotomies, arising one per segment in $\frac{1}{4}$ spiral sequence in erect branches, and quickly deciduous; scar-cells on both erect and prostrate branches; tetra-

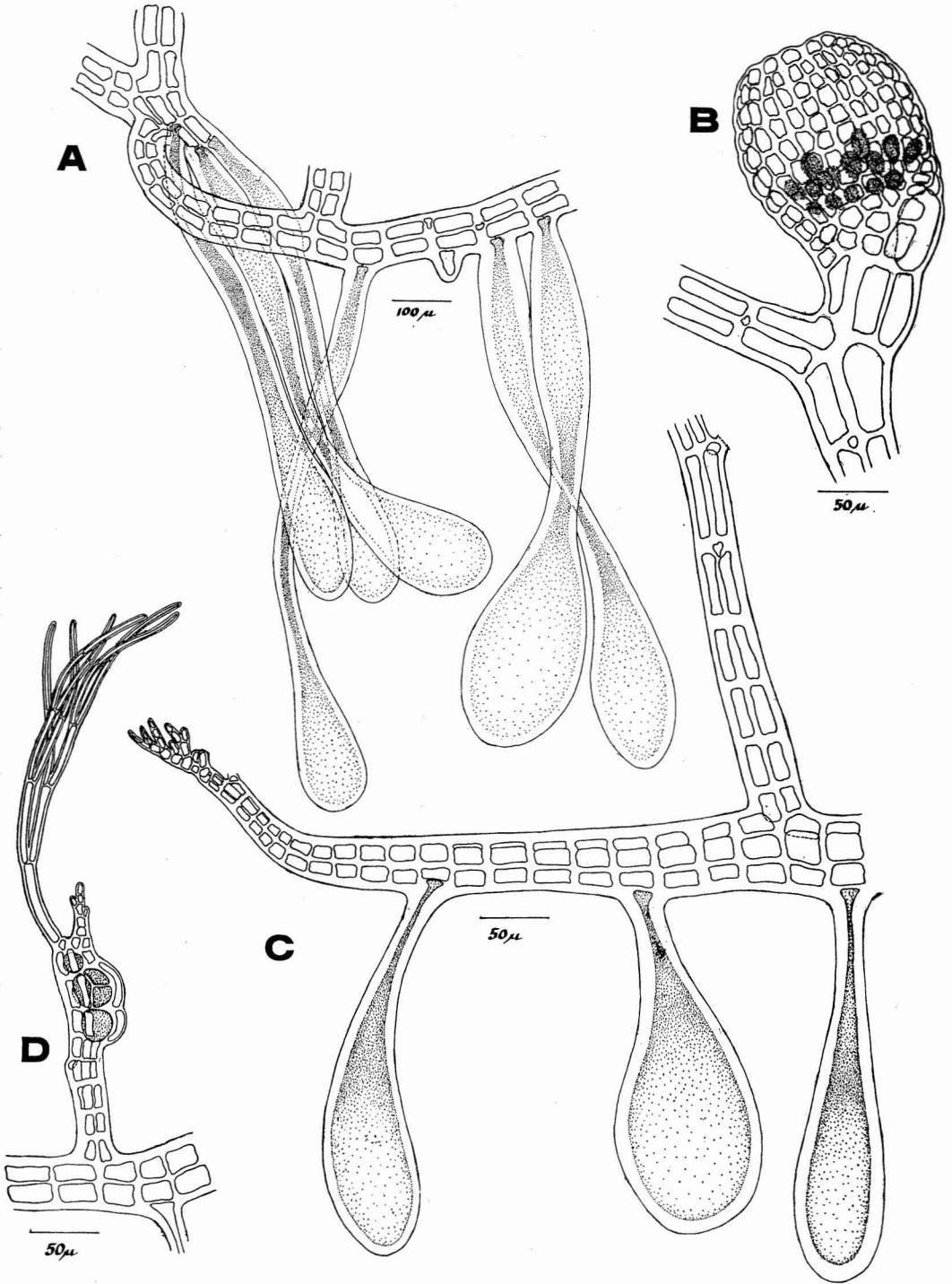


FIG. 4. *A*, *Polysiphonia rubrorhiza*, showing saccate pigmented rhizoids arising from the base of erect branch, and from prostrate branches. From the type collection. *B*, *Polysiphonia rubrorhiza*, immature cystocarp (from type collection). *C*, *Polysiphonia saccorhiza*, prostrate branch with erect branch and saccate pigmented rhizoids. *D*, *Polysiphonia saccorhiza*, tetrasporic erect branch.

sporangia about 65μ in diameter in short spiral series in the ultimate branches; cystocarps globular with a suggestion of a bracket-like base produced by an extension of the short pedicel; spermatangial branches arising as a primary branch of a trichoblast.

Algae epiphyticae ad 8 mm alt., e penicillo basali rhizoideorum saccatorum rubrorum ad 125μ long. quae hospitem penetrant et ut cellulae discretae a cellulis pericentralibus separantur, enascentes; rami erecti $75-100\mu$ diam., ramos laterales intervallis plerumque 5-10 segmentorum qui sine coniunctione trichoblastis enascent, habentes; cellulae pericentrales 4, ecorticae, segmentis aequae longis ac latis aut longioribus; trichoblastae ad 680μ long., 2-4 dichotomias, una in unoquoque segmento in $\frac{1}{4}$ spira in ramis erectis, habentes; cellulae-cicatrices in ramis et erectis et prostratis; tetrasporangia in serie brevi spirali in ramis ultimis innata; cystocarpi globosi; rami spermatangiales ut ramus primarius trichoblastae enascentes.

TYPE: D. 18740D, tetrasporic, cystocarpic and spermatangial, epiphytic on a species of *Codium* awash at Midway I., after a severe storm, and collected by C. H. Lamoureux, Dec. 16, 1962. It is represented by fluid-preserved material and several glucose microslide mounts. It is the only collection of this species.

The rhizoids of this alga are confusingly similar to those of *P. saccorbiza*, which was growing on the same host. From that species it differs in the chiefly erect habit in contrast to the chiefly prostrate habit of *P. saccorbiza*. Also the erect branches are much higher and branched, whereas the erect branches of *P. saccorbiza* are rarely if ever branched.

It may be that this is the same alga to which Cribb (1956:135) refers, when he mentions a "different *Polysiphonia* on *Codium*" with both inflated and non-inflated rhizoids. Along with the two Midway algae with inflated rhizoids were several specimens of a separate plant with non-inflated and non-pigmented rhizoids, which seem to be best identified with *P. savatieri* Hariot.

Polysiphonia saccorbiza (Collins and Hervey) comb. nov.

Lophosiphonia saccorbiza Collins and Hervey (1917:127)

Figs. 4C, 4D

Epiphytic algae with prostrate branches $50-70\mu$ in diameter and with segments $1.0-1.3-$

(2+) diameters long, attached by unicellular rhizoids cut off by a cross-wall from the center of the pericentral cells; rhizoids soon becoming prominently saccate, to 140μ in diameter in the saccate tips and to 500μ long, deeply pink with numerous discoid chromatophores about 1μ in diameter distributed around the periphery of the cell; all branches are prostrate or tend soon to become more or less prostrate except for the short erect reproductive branches, and all morphologically prostrate branches bear the saccate rhizoids, although many of the rhizoids do not penetrate the host tissue; branches arising endogenously and at intervals of mostly 6-12 segments; erect reproductive branches are up to 550μ high and about 40μ in diameter with segments $1.5-2.0$ diameters long. They bear trichoblasts on upper parts, one per segment, which are mostly not well developed but are occasionally to 300μ long with 2 dichotomies; trichoblasts are soon shed, leaving scar-cells one per segment in $\frac{1}{4}$ spiral sequence and often prominent wall-scars at the point of abscission; scar-cells infrequent on strictly prostrate branches; tetrasporangia $40-50\mu$ in diameter, in short series in the erect branches, much distending the narrow segments; cystocarps 1-2 near branch tips, mature pericarps subglobular, to 210μ in diameter and 240μ long with cells well separated and tending to occur in transverse as well as longitudinal rows; spermatangial branches arising as a primary branch of a trichoblast.

A single collection D. 18739A, tetrasporic, cystocarpic, and male, epiphytic on *Codium* sp., was made by C. H. Lamoureux, Midway I., Dec. 16, 1962.

The Midway plants differ from the original description of the Bermuda plants in minor respects: (1) the erect branches are much shorter and are not noticeably contracted at the base; (2) the trichoblasts are not well developed; (3) the rhizoids usually do not penetrate the host, but are abundant on the preponderantly prostrate branches, or potentially prostrate laterals; (4) the rhizoids are somewhat smaller; (5) the cystocarps are larger (probably a matter of maturity).

Since these specimens of *P. saccorbiza* were found on the same host as was *P. rubrorbiza*, and since the two entities have very similar saccate and pigmented rhizoids, the question

naturally arises as to whether they are distinct species. However, the growth habit is very different: *P. saccorhiza* is chiefly prostrate with relatively short unbranched laterals, whereas *P. rubrorhiza* has few or no prostrate branches and is primarily erect, with much higher erect branches with several laterals.

P. saccorhiza was reported from southeastern Queensland by Cribb (1954). Later Cribb (1956) decided his plant was *P. platycarpa*. Since the Queensland plant lacked the trichoblasts and scar-cells, it can hardly be identified with the Midway specimens.

Howe (in Britton, 1918) states that *L. saccorhiza* occasionally grows somewhat free from the substratum. In the Midway specimens the prostrate branches may similarly grow free from the substratum, but their identity as prostrate branches is not lost. Howe states, furthermore, that the development of free branches suggests the genus *Polysiphonia* rather than *Lophosiphonia*. This indicates that he considered the prostrate habit as the chief distinguishing feature of *Lophosiphonia*, a view difficult to maintain.

It should be noted here that Doty and Menez (1960) reported the occurrence of pigmented rhizoids on a species of *Tiffaniella*. This alga was likewise epiphytic on a species of *Codium*.

Polysiphonia savatieri Hariot (1891:226)
Figs. 37, 38

Epiphytic algae, mostly 1 cm high or less, from a basal attachment or a briefly prostrate or assurgent base attached by unicellular rhizoids cut off by a cross-wall from the proximal end of the pericentral cell; pericentral cells 4, ecorticate, with segments in the median parts of erect branches, mostly about 1 diameter long; median parts of erect branches mostly 80–140 μ in diameter; all branches arising independent of trichoblasts mostly at intervals of 7–10 segments; trichoblasts one per segment in $\frac{1}{4}$ spiral sequence, with mostly 2–3 dichotomies, to 140 μ long, soon deciduous, leaving persistent scar-cells; tetrasporangia 53–60 μ in diameter in spiral series in the terminal branches which are usually considerably distended; cystocarps globular 130–145–(220) μ in diameter, to somewhat urceolate, with pericarp cells more or less isodiametric in surface view, and with ostiolar cells

sometimes prominently enlarged; spermatangial branches 130–170 μ \times 45–56 μ arising as a primary branch of a trichoblast with or without a sterile tip.

COLLECTIONS STUDIED: MIDWAY ISLAND—D. 18727, sterile, on *Codium*, awash, legit C. H. Lamoureux, Dec. 16, 1962; HAWAIIAN ISLANDS—H. 65–15, on *Centroceras* in shallow water near Coconut I., Kaneohe Bay, Oahu, Mar. 20, 1965; H. 65–49.5, cystocarpic, on a small seagrass, Waikiki Beach, Oahu, Apr. 26, 1965; H. 65–86.1, tetrasporic, on *Pocockiella*, legit M. Kajimura, Diamond Head Beach, Oahu, May 1965; H. 65–50, tetrasporic, male, with very delicate trichoblasts, on *Codium*, on the bottom of a 2-ft pool at low tide, Wawamalu Beach, Oahu, May 1, 1965; D. 20144, on *Sargassum*, in tidepools, Kamoamo, Puna, Island of Hawaii, Mar. 21, 1961; TUAMOTU ISLANDS—D. 11858.3, male, 11860B, tetrasporic, transect area, Otetou, Raroia Atoll, legit M. S. Doty and Jan Newhouse, Aug. 21, 1952; AMERICAN SAMOA—T. 262A, male, at high water line 20 m from shore, Nuuli Village, Tutuila I., Sept. 8, 1963; MARSHALL ISLANDS—D. 9603A, cystocarpic, male, on *Galaxaura*, awash at Ine Village, Ine I., Arno Atoll, legit Leonard Horwitz, Aug. 8, 1951; CAROLINE ISLANDS—D. 15586.3A, cystocarpic, male, on *Padina*, on the reef at Koror I., Palau Group, legit E. Menez, Sept. 5, 1960; D. 15654.8, tetrasporic, and D. 15656.1, male, cystocarpic, on *Sargassum*, on the reef at Pulo Anna I., legit E. Menez, Sept. 3, 1960; D. 23423, cystocarpic, on seagrass, on the reef near Utwa Village, Kusiae I., legit E. Menez, July 17, 1960; PHILIPPINE ISLANDS—D. 18173.1, tetrasporic, cystocarpic, male, Mangagoy, Bislig, Surigao, legit E. Menez, June 29, 1958. Also several unnumbered collections by D. P. Abbott, 1957, as follows: on *Chaetomorpha*, tetrasporic, male, northeast coast of Siasi I., Sulu Sea, Jan. 28; on *Dictyota* sp., tetrasporic, cystocarpic, male, on sand flats, Laminusa, Siasi I., Sulu Sea, Jan. 29; on turtle grass east of Laminusa, Jan. 30; on other algae, tetrasporic, on reef west of Cagayan Sulu, Sulu Sea, Feb. 28; on other algae, tetrasporic, on reef, Pasig Bay, Balabac I., Mar. 1; on *Thalassia* and *Acanthophora*, tetrasporic, cystocarpic, Gnat Reef, Balabac I., Mar. 4.

A number of additional collections have been identified with this species with considerable misgivings. They are perhaps closer to *P. sphaerocarpa* as at present interpreted. A portion of

the type collection of *P. savatieri* collected at Yokosuka, Japan by M. Savatier was examined through the kindness of the Natural History Museum, Paris. The plants of this collection

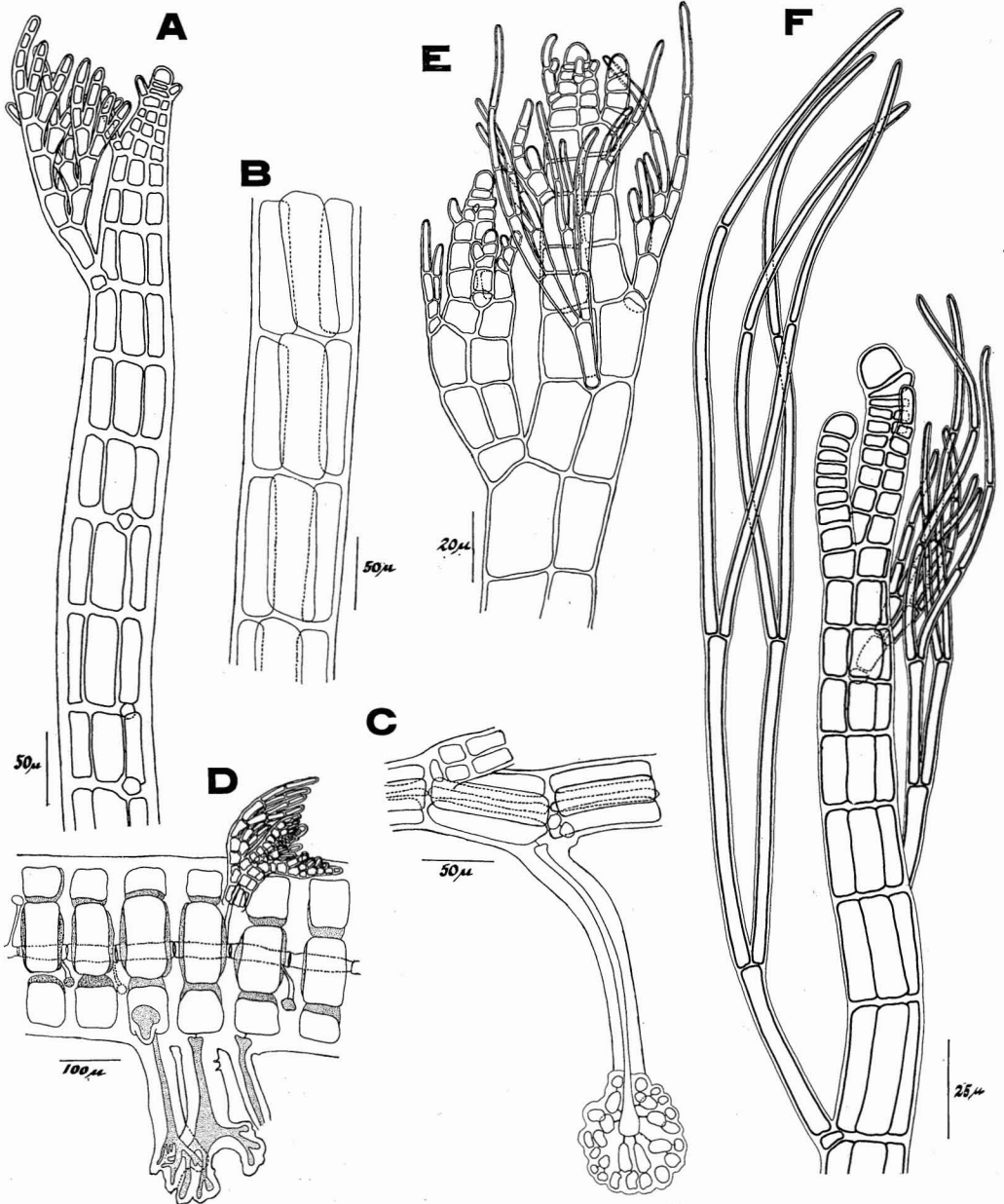


FIG. 5. *A*, *Polysiphonia setacea*, tip of erect branch. *B*, *Polysiphonia setacea*, portion of an erect branch, showing oblique orientation of pericentral cells. *C*, *Polysiphonia setacea*, prostrate branch and rhizoid with enlarged apex and multicellular branches. *D*, *Polysiphonia sparsa*, portion of prostrate branch. *E*, *Polysiphonia sphaerocarpa* var. *distans*, tip of branch. *F*, *Polysiphonia subtilissima* var. *abbottae*, apex of branch with abundant trichoblasts (from type material).

are abundant epiphytes 1.3–2.0 cm high, each basally attached by a tuft of rhizoids with little or no prostrate portion. In most details the plants identified with *P. savatieri* in this paper agree with the type. They differ from the type in minor respects: (1) they are smaller and more delicate; (2) the segments are somewhat longer; (3) there are occasional prostrate branches; (4) branching is mostly more lax, with basal unbranched axis occasionally up to 33 segments long.

The similarities between *P. savatieri*, *P. sphaerocarpa*, *P. mollis*, *P. simplex* (cf. Hollenberg, 1942b:782), and several other species in the genus are such as to raise questions concerning their distinctness. However, it seems best to continue to recognize them as distinct species for the present at least. A study of the early developmental stages of *P. sphaerocarpa* and *P. mollis* might be helpful in determining whether or not *P. savatieri* is merely a fruiting developmental stage or an ecological form of one or more of these species. D. 19143T3, cystocarpic, is identified with *P. savatieri* even though it is only 2 mm high. It was growing on a species of *Galaxaura* and was dredged from 15 fa, at Ilio Pt., Molokai, Hawaii, Sept. 7, 1959. This specimen may be merely a young but fruiting plant, or its minute size may be related to the habitat.

Polysiphonia scopulorum Harvey (1854:540)
Lophosiphonia scopulorum (Harvey) Womersley (1950:188)

Plants mostly 0.5–1.0 cm high from prostrate branches 50–85 μ in diameter and with segments mostly about 1 diameter long, attached by frequent unicellular rhizoids with digitate tips, which remain in open connection

with the pericentral cells bearing them; erect branches similar to prostrate branches, mostly 40–60 μ in diameter, with segments mostly 1 diameter long but often shorter or longer, arising endogenously mostly at intervals of 2–3 segments, simple or with occasional lateral cicatrigenous branches; 4 pericentral cells, ecarticate; trichoblasts and scar-cells infrequent and limited mostly to the tips of erect branches, often short but commonly 200–400 μ long or longer; scar-cells not occurring in prostrate branches; tetrasporangia 40–45 μ in diameter, in straight series, sometimes greatly distending the segments; spermatangial branches arising from the entire trichoblast primordium or in pairs from the primary branches.

TYPE LOCALITY: Fremantle, Western Australia.

P. scopulorum var. *scopulorum* (Harvey) comb. nov.

Figs. 6F, 30, 31, 33, 36

Mostly 5–8 mm high and with segments mostly shorter than broad; erect branches arising mostly at intervals of 2–3 segments from the prostrate branches and usually distinctly narrowed at the base (Figs. 30, 31). The rhizoids of this variety are sometimes finely and repeatedly branched (Fig. 31) or ornately discoid (Fig. 30) in the case of epiphytic specimens.

Examination of the type material kindly loaned from the herbarium at Trinity College, Dublin, leaves little doubt that numerous specimens from the tropical Pacific Ocean are to be identified with *P. scopulorum* var. *scopulorum*. From var. *villum* it differs in the coarser erect branches with consistently shorter segments and narrowed base. Also the erect branches are more

KEY TO THE VARIETIES OF *Polysiphonia scopulorum*

- 1. Erect branches mostly less than 1 mm high 2
- 1. Erect branches 5 or more mm high at maturity 3
- 2. Epiphytic algae with erect branches mostly less than 500 μ high, unbranched, and bearing relatively huge trichoblasts var. *macrotrichia*
- 2. Saxicolous algae with erect branches mostly more than 500 μ high, frequently branched, and bearing trichoblasts of more moderate size var. *minima*
- 3. Erect branches commonly arising at intervals of 2 segments, with segments in median parts mostly shorter than broad var. *scopulorum*
- 3. Erect branches mostly at more distant intervals, with segments in median parts mostly longer than broad var. *villum*

commonly branched in var. *scopulorum* and arise at more frequent intervals (commonly 2-3 segments) from the prostrate branches. Tricho-

blasts are mostly larger and coarser in var. *scopulorum*. Further observations are needed to determine whether or not the paired arrange-

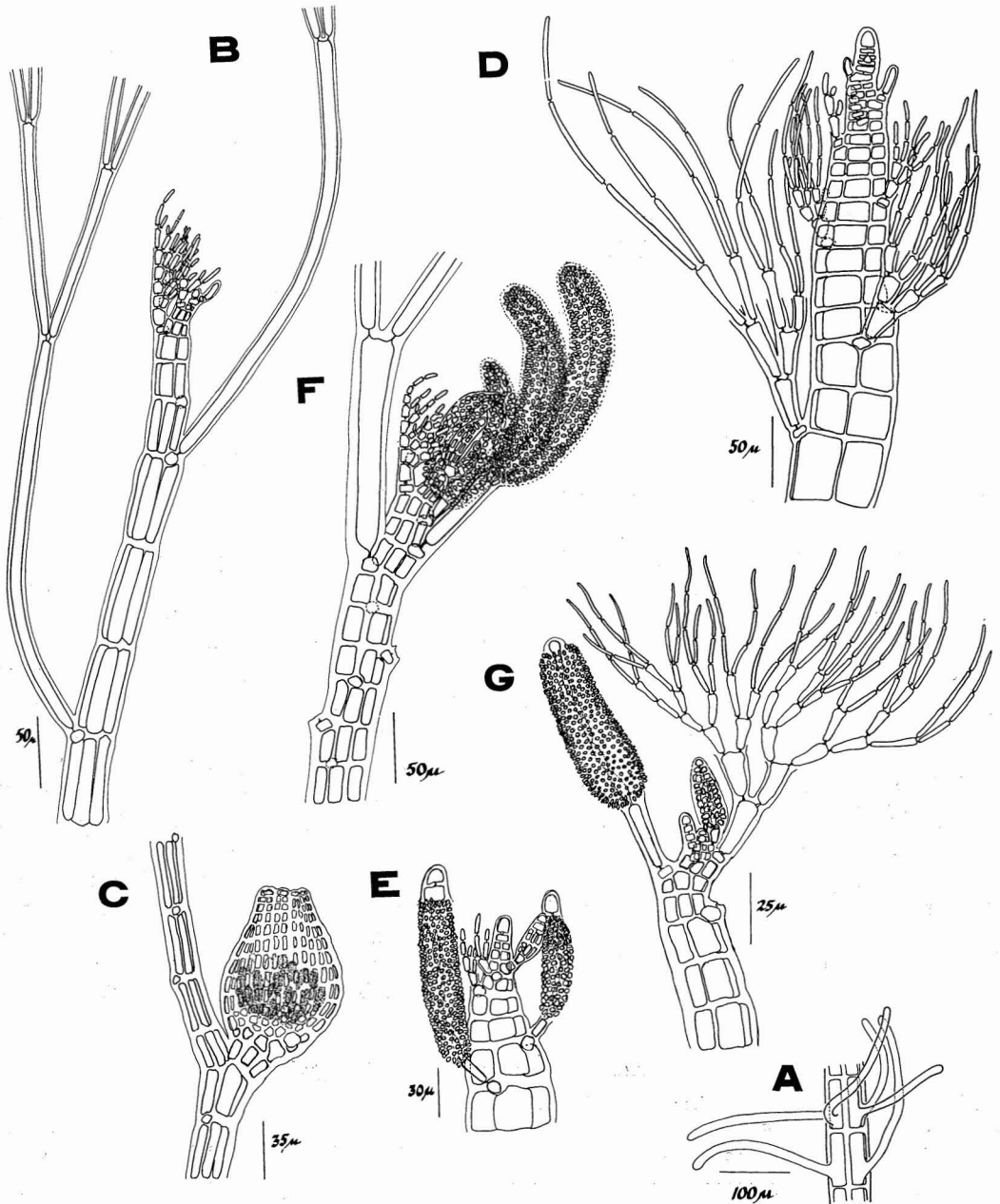


FIG. 6. A, *Polysiphonia subtilissima* var. *abbotiae*, whorl of rhizoids on erect branch. B, *Polysiphonia tenuis*, apex of erect branch. C, *Polysiphonia tenuis*, cystocarp. D, *Polysiphonia upolensis*, branch apex. E, *Polysiphonia upolensis*, branch apex with spermatangial stichidia. F, *Polysiphonia scopulorum* var. *scopulorum*, branch apex with paired spermatangial stichidia. G, *Polysiphonia scopulorum* var. *minima*, branch apex with spermatangial stichidia.

ment of spermatangial branches (Fig. 6F) is a characteristic feature of this variety.

COLLECTIONS EXAMINED: HAWAIIAN ISLANDS—T. 633, on coral reef of Bird I., Pearl and Hermes Reef, Aug. 1964; D. 9908A, tetrasporic, on rocks between stream entrance and Papaa Bay, Aliomanu, Kauai, Feb. 3, 1952; D. 19633, tetrasporic, on wave-washed basalt bench at low tide, south side of Hanauma Bay, Oahu, Feb. 3, 1962; H. 65-38, Wawamalu Beach, Oahu, legit G. Collins, Feb. 28, 1965; D. 22289.5, low mats, intertidal, Kahe Pt. Beach Park, Oahu, legit R. Tsuda and R. Buggeln, Jan. 3, 1965; D. 18720.1, on 1740 lava flow, Maui, Dec. 17, 1955; D. 22401.3, basalt shore line, Papawai Pt., northwest of Maalaea, Maui, legit H., T., and B., Apr. 19, 1965; D. 22435, extensive patch on boulders near Camp Pecusa, leeward Maui, legit H., T., and B., Apr. 19, 1965; D. 22549.1, on *Pocockiella*, on large boulders, Kahakuloa, Maui, legit H., T., and B., Apr. 21, 1965; D. 19730A, on coral reef flats, Kumimi, Molokai, Dec. 29, 1953; D. 17199A1, with *Jania*, etc. near landing, Kaimu Bay, Puna, Island of Hawaii, Jan. 27, 1953; D. 19252, tetrasporic, on wave-dashed basalt, Koneleau study area, Puna, Island of Hawaii, Dec. 23, 1959; LINE ISLANDS—L. 2700.6, tetrasporic, on *Dictyosphaeria*, in algal mat, near breaking-wave zone, Jarvis I., Nov. 16, 1964; L. 2701.6, tetrasporic, L. 2702.3, L. 2703.4, and L. 2706.5, tetrasporic, on coral heads exposed at low tide, southwest reef, Jarvis I., Nov. 16, 1964; L. 2804.6 and L. 2805.2, algal mats on rocks exposed at low tide, western reef, Christmas I., Nov. 23, 1965; MARQUESAS ISLANDS—D. 19798A, tetrasporic, on surf-swept rock, Huta Atua Bay, Nuku Hiva I., legit John E. Randall, July 16, 1957; TUAMOTU ARCHIPELAGO—D. 11160B1, tetrasporic, on dead coral, reef near lagoon entrance, Takeke, Raroia Atoll, legit M. S. Doty and Jan Newhouse, July 9, 1952; D. 11858.6, on dead coral, and D. 11859.2 on crustose corallines, near Otetou, Raroia Atoll, legit M. S. Doty and Jan Newhouse, Aug. 21, 1952; SOCIETY ISLANDS—D. 18401B, tetrasporic, on reef at Papeete Harbor, Tahiti, legit J. Randall, Mar. 12, 1956; PHOENIX ISLANDS—L. 2451.4, on *Halimeda* sp., McKean I., Oct. 21, 1964; AMERICAN SAMOA—T. 752B,

on wave-washed basalt shore, Vatia Bay, Tutuila I., legit R. Buggeln, Aug. 1964; T. 897A, on basalt rock near shore, Lion's Head, Tutuila I., legit R. Buggeln, Aug. 7, 1964; MARIANA ISLANDS—D. 20132, tetrasporic, on dead coral, Guam, legit E. Menez, Oct. 12, 1960; NEW ZEALAND—A herbarium mount in the Allan Hancock collections at the University of Southern California is from the Lindauer Herbarium and was collected at Long Beach, N. Z., and identified as *P. macra* (Harvey) Falkenberg. It agrees very well with other collections of *P. scopulorum* var. *scopulorum*.

P. scopulorum var. *villum* (J. G. Agardh) comb. nov.

P. villum J. G. Agardh (1863:941); *Lophosiphonia villum* (J. G. Agardh) Setchell and Gardner (1903), Hollenberg (1942a: 535)

Fig. 7A

This variety is usually saxicolous and has erect branches mostly 5-8 mm high with segments mostly longer than broad, arising at intervals of mostly 4-6 segments. The branches are more slender than those of var. *scopulorum*, arise mostly at more distant intervals, and are not noticeably narrowed at the base.

Cribb (1956:138) places *P. villum* in synonymy with *P. scopulorum*, the latter having priority. A number of specimens from the Atlantic examined by the writer and most of those from the Pacific coast of the United States conform more closely to the description given for *P. villum*. The latter is retained as a variety.

TYPE LOCALITY: "Ad littus americanae tropica," probably on the Pacific coast of Mexico.

COLLECTIONS EXAMINED: HAWAIIAN ISLANDS—D. 22502, tetrasporic, intertidal, Beach Park near Honolulu, Maui, legit H., T., and B., Apr. 20, 1965; D. 20209, in algal turf, Kaena Ponds, Puna District, Island of Hawaii, Mar. 19, 1965; TUAMOTU ARCHIPELAGO—D. 11160B, coating on coral, entrance to lagoon Raroia Atoll, July 9, 1952; SOCIETY ISLANDS—a collection, D. 14701, by J. Randall, Moorea I., Tahiti, May 30, 1956; AMERICAN SAMOA—T. 678B, tetrasporic, in shallow water near the shore, Vatia Bay, Tutuila I., legit R. Buggeln,

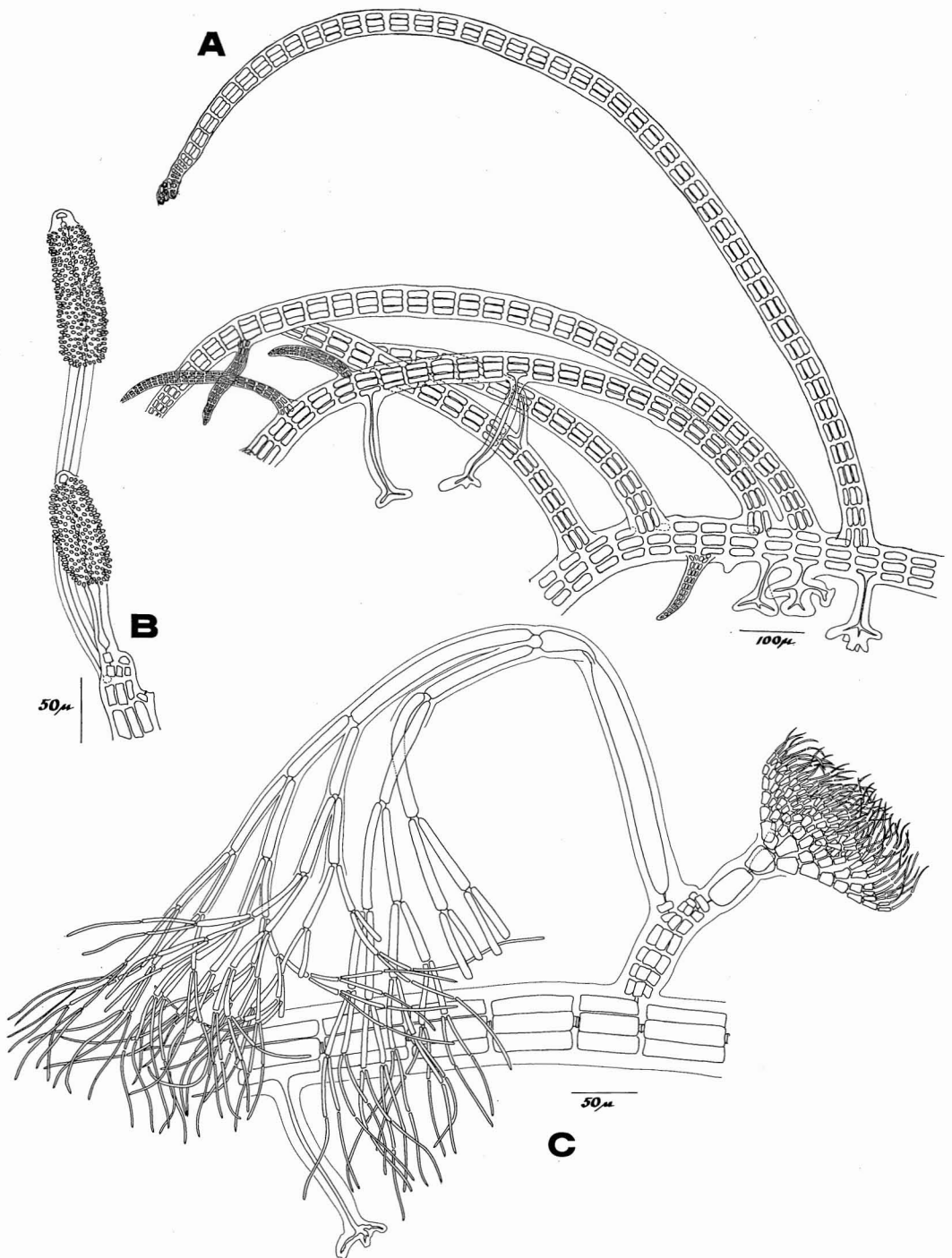


FIG. 7. *A*, *Polysiphonia scopulorum* var. *villum*, young plant with shorter segments than usual. *B*, *Polysiphonia scopulorum* var. *minima*, paired and long-stipitate spermatangial branches. *C*, *Polysiphonia scopulorum* var. *macrotrichia*, prostrate branch with short erect branch bearing huge trichoblasts (from the type slide).

Aug. 1964; MARSHALL ISLANDS—D. 9215A, and D. 9536.1, on a coral reef, transect area, Arno Atoll, legit Leonard Horwitz, July 30, 1951; H. 48-Y58.3, on coral heads, Biihiri I., Eniwetok Atoll, July 26, 1948; CAROLINE ISLANDS—D. 15586.1, on *Padina* sp. on a reef, Koror I., Palau Group, legit E. Menez, Sept. 5, 1960; D. 21708.3, tetrasporic, reef flat, Epwelkapw I., Ponape Group, legit E. Menez, June 20, 1960; PHILIPPINE ISLANDS—D. 18101A, on a shell at a depth of 3–6 ft near Davao, Mindinao, legit E. Menez, June 22, 1958; VIET NAM—Da. 11218, tetrasporic, spermatangial, on rocks near a seawall, Nhatrang, Feb. 2, 1953; INDIAN OCEAN—David Sigeo 29, lagoon reef flat, Gan I., Maldive Islands, July–Sept. 1964; PACIFIC AMERICAN MAINLAND—variety *villum* is well represented in collections from southern California and from Pacific Central America; T. 1000A, from tide pools on wave-washed basalt, Playa Coco, Guanacaste, Pacific Costa Rica, collected June 21, 1965, is representative of these collections; FLORIDA—Da. 7287, Da. 7289, tetrasporic, Da. 7293, Cutler near Miami, May 5, 1949; Da. 7314, tetrasporic, along a causeway, Biscayne Bay, Apr. 15, 1949. BERMUDA—A. J. Bernatowicz 53–358.1, intertidal turf, Bailey's Bay, May 14, 1953.

A collection by Louis Williams, No. 910 from Cape Lookout, N. Carolina, Aug. 1946, likewise seems representative of this variety. A minute variant form is H. 65–25.1, with few or no trichoblasts. Half embedded in a coral crust, this specimen was dredged from a depth of 2–3 fa in Kaneohe Bay, Oahu, Hawaii, Mar. 20, 1965.

P. scopulorum var. *macrotrichia* var. nov.

Fig. 7C

Diminutive algae with creeping branches to 70 μ in diameter, with segments 1.5–2.0 diameters long, attached by occasional to frequent unicellular rhizoids which are not cut off from the pericentral cells as separate cells; erect branches to 225 μ high but mostly much shorter with segments mostly about 1 diameter long, arising endogenously at irregular intervals of about 8–10 segments; pericentral cells 4, ecorticate; trichoblasts one per segment in $\frac{1}{4}$ spiral

sequence on a few terminal segments of erect branches only, to 700 μ long with 6–7 dichotomies and very delicate tips and with a basal cell to 170 μ long and 20–28 μ in diameter, mostly soon deciduous leaving relatively prominent scar-cells and wall scars; reproductive structures not observed.

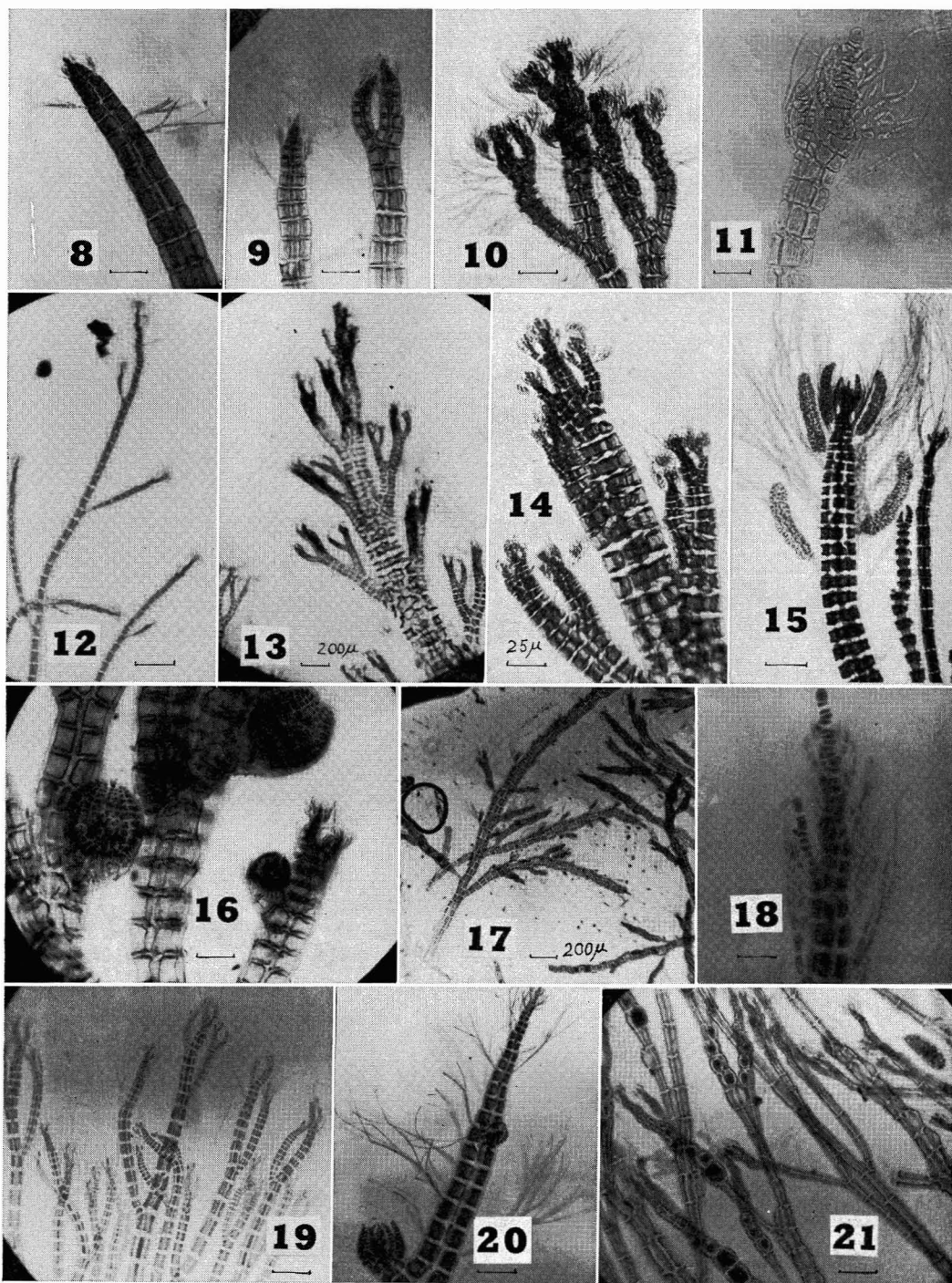
Algae diminutivae, proprietates speciei basicas praebentes, ramis repentibus, autem, relative amplis, ad 70 μ diam. et ramis erectis plerumque brevissimis, intervallis 8–10 segmentorum enascentibus, paucas trichoblastas relative magnas ad 700 μ long. ferentibus.

TYPE: D. 11514A1, collected by M. S. Doty and Jan Newhouse from a depth of 3–4 ft in a reef channel north of Oneroa, Raroia Atoll in the Tuamotu Archipelago, Aug. 5, 1952. It is represented by a glucose mount.

ADDITIONAL COLLECTIONS: D. 21079.1, tetrasporic, on other algae, Helen reef, Western Caroline Islands, legit E. Menez, Aug. 28, 1960; D. 23112.4, on *Microdictyon* sp. on a reef on the eastern side of Ifaluk and Falalap Islands, Caroline Islands, legit E. Menez, Aug. 10, 1960. The latter collection has the characteristic short erect branches from extensive creeping branches, but the trichoblasts are not large as in the type collection. More collections of this alga are needed to fully establish the distinctive features, especially reproductive features.

It is interesting to note that a very similar alga was collected by Dr. Harold J. Humm. It was attached to *Batophora*, at a depth of 15 ft, at Lower Matecumbe Key, Monroe County, Florida, Feb. 19, 1965. In most detailed features the Florida plant is close to the Raroia collection, differing chiefly in size. The diameter of the prostrate branches of the Florida specimens is more than twice as large as that of the Raroia plants, and the trichoblasts are about twice as long. However, this is in keeping with the generally diminutive nature of most *Polysiphonia* species from the central Pacific. The Florida plants were likewise sterile.

In its chiefly prostrate habit with very short erect branches *P. scopulorum* var. *macrotrichia* resembles *P. anomala* and *P. delicatula*, from which it differs chiefly in the rhizoids which remain in open connection with the pericentral cells.



FIGS. 8-21. (Scale = 100 μ , except as indicated.) 8, 9, *Polysiphonia apiculata*, vegetative branch tip. 10, *Polysiphonia sphaerocarpa* var. *filifera*, branch tips with immature tetrasporangia. 11, *Polysiphonia flaccidissima*, a delicate variant with branched trichoblasts associated with young branch. 12, *Polysiphonia flaccidissima* var. *decimera*, showing branching pattern (from the type collection). 13, *Polysiphonia banccockii*,

P. scopulorum var. *minima* var. nov.

Figs. 6G, 7B, 34

Minut algae with creeping branches 40–50 μ in diameter, with segments mostly shorter than broad, attached by unicellular rhizoids which are not cut off from the pericentral cells as separate cells and which commonly have digitate tips; erect branches 200–300 μ (to 1 mm) high and 35–40 μ in diameter, unbranched or occasionally branched near the base, arising endogenously at frequent but irregular intervals, with segments mostly about 1 diameter long; trichoblasts commonly relatively large (to 750 μ with basal cell to 200 μ long and 28 μ in diameter), with 4–6 dichotomies, arising at irregular intervals on median parts and often one per segment in $\frac{1}{4}$ spiral sequence in upper parts of erect branches, soon shed; scar-cells not present in prostrate branches; tetrasporangia 35–40 μ in diameter, somewhat protuberant, in straight or slightly spiralling short series in the erect branches; cystocarps globular to ovoid, to 130 μ in diameter, with cells of the ostiolar rim not enlarged; spermatangial branches oblong 115–145 \times 40–45 μ , with a small sterile terminal cell and a stipe mostly 35–50 μ long but occasionally to 180 μ long, arising from the entire trichoblast primordium.

Algae minutae proprietates speciei generales praebentes, minores, autem, maxima ex parte, ramis prostratis 40–50 μ diam. et ramis erectis ad 1 mm alt., intervallis satis crebris endogene enascentibus, et trichoblastas relative magnas ad 750 μ long., quae 4–6 dichotomias habent, ferentes; rami spermatangiales in stipitibus longioribus binatim producti.

TYPE: H. 65–113.4, tetrasporic, cystocarpic and male, consists of three glucose slides and fluid-preserved material. It was collected by R. S. Jones at a depth of 1–2 m, about 20 m shoreward from the outer reef margin north of North I., Johnston I., Apr. 22, 1965. It was growing on dead coral.

ADDITIONAL COLLECTIONS: D. 11859.2, sterile, on encrusting corallines, sea reef near Otetou, Raroia, Tuamotu Archipelago, collected by M. S. Doty and Jan Newhouse, Aug. 21, 1952; D. 23112.7, tetrasporic, on *Halimeda*, on reef at eastern side of Ifaluk I., Caroline Islands, collected by E. G. Menez, Aug. 10, 1960.

In the short segments this variety is similar to var. *scopulorum*, but it is a much smaller plant and more delicate and, unlike var. *scopulorum*, the spermatangial branches have a terminal sterile cell and at least sometimes long stipes (Fig. 7B). They may occur in pairs, as in *P. scopulorum*. This instance in which the stipe of the spermatangial branch was 180 μ long may not be representative of the variety.

Polysiphonia setacea sp. nov.

Figs. 5A, 5B, 5C

Chiefly saxicolous algae, relatively setaceous, commonly forming extensive patches to 1 cm high from prostrate branches attached by rhizoids, which are at first unicellular and cut off as separate cells mostly from the distal end of the pericentral cells, but at maturity mostly develop multicellular tips: erect branches to 1 cm high, arising mostly cicatrigenously, mostly unbranched, composed of segments 65–70–(100) μ in diameter and 0.7–1.5–(2.0) diameters long with walls relatively thick (5–8 μ); pericentral cells 4, ecorticate; trichoblasts relatively coarse, with 1–(3) dichotomies, mostly much reduced and quickly deciduous; scar-cells in upper parts one per segment in $\frac{1}{4}$ spiral sequence but mostly at intervals of 2–3 segments below, and at intervals of 1–3 segments on prostrate branches; pericentral cells in erect branches commonly slightly oblique rather than in straight longitudinal rows; tetrasporangia in slightly spiral series, up to 30 in the series, in terminal parts of erect branches; somewhat distending the segments; sexual plants unknown.

upper portion of erect branch. 14, *Polysiphonia hancockii*, tip of erect branch. 15, *Polysiphonia poko*, tip of erect branch with spermatangial stichidia. 16, *Polysiphonia hawaiiensis*, with cystocarps. 17, *Polysiphonia beandettii*, with fruiting lateral branches. 18, *Polysiphonia profunda*, tip of erect branch showing origin of lateral branch in association with a trichoblast (from the type slide). 19, *Polysiphonia subtilissima*, tips of erect branches. 20, *Polysiphonia profunda*, tip of erect branch, with young cystocarp and persistent trichoblasts. 21, *Polysiphonia sphaerocarpa* var. *sphaerocarpa*, a slender form with tetrasporic branches narrowed at the base.

Algae praecipue saxicolae, relative setaceae, maculas amplas ad 1 cm alt. e ramis prostratis vulgo formantes, per rhizoidea quae primum unicellularia et ut cellulae discretae plerumque ab extremo distali cellularum pericentralium separata, matura, autem, cacumina multicellularia plerumque efficient, affixae; rami erecti ad 1 cm alt., saepius cicatrigenae enascentes, saepius non ramosi, e segmentis 65–70–(100) μ diam, et 0.7–1.5–(2.0) longioribus quam lata, membranas relative crassas (5.8 μ) habentibus, compositi; cellulae pericentrales 4, ecorticae; trichoblastae relative grossae, 1–(3) dichotomias habentes, plerumque valde reductae et cito deciduae; cellulae-cicatrices in partibus superioribus, una in unoquoque segmento in $\frac{1}{4}$ spira, plerumque, autem, intervallis 2–3 segmentorum infra et 1–3 segmentorum in ramis prostratis; cellulae pericentrales in ramis erectis vulgo paululum obliquae et non in ordinibus rectis longitudinalibus; tetrasporangia in serie aliquantulum spirali usque in ad 30 in serie, in partibus terminalibus ramorum erectorum; segmenta satis distendentia; plantae sexuales ignotae.

TYPE: D. 14696, on rocks in algal turf in a high tide pool near Koko Head Parking Area, eastern Oahu, legit E. Choy, Nov. 14, 1954.

ADDITIONAL COLLECTIONS EXAMINED: HAWAIIAN ISLANDS—D. 10667, north entrance shore of Hanauma Bay, Oahu, May 3, 1953; D. 22301.1, in tidepools, northeast bench of Hanauma Bay, Oahu, legit R. Tsuda, Jan. 17, 1965; a collection by G. F. Papenfuss, Hanauma Bay, Oahu, Mar. 30, 1941; D. 19906A, Ilio Point, Molokai, Dec. 30, 1953; D. 22397, intertidal, in algal turf, Papawai Point, Maui, legit H., T., and B., Apr. 19, 1965; D. 22409.3 and D. 22410.4, in algal turf, 0.5 miles west of Papawai Point, Maui, legit H., T., and B., Apr. 19, 1965; D. 13464.1, on a basalt ledge, west lip of Pohoiki Bay, Island of Hawaii, Nov. 10, 1956; JOHNSTON ISLAND—T. 1221, at a depth of 4 m, coral reef, northeast of East I., legit R. Buggeln, Aug. 20, 1965; SOCIETY ISLANDS—a collection, D. 14698, by J. Randall, Tahiti, Mar. 12, 1956; AMERICAN SAMOA—T. 359, on *Caulerpa*, reef flat near shore, Amanave Village, Tutuila, Sept. 4, 1963; FIJI ISLANDS—D. 12123.2, Navuevu Cuva, Singtoka, Viti Levu, Sept. 22, 1952; MARSHALL ISLANDS—G. 502, on *Halimeda* in the lagoon at a depth of 19 m, Eniwetok Atoll, Aug. 29, 1955; G. 781, on *Halimeda* at a depth of 53 m, in the lagoon, Eniwetok Atoll, Sept. 7, 1955; a collection, probably also by Gilmartin, tetrasporic, in algal turf at the outer edge of the reef, in front of

the Marine Biology Laboratory, May 4, 1955; D. 9693C, on *Halimeda* sp., on the lagoon side of Ine Village, Arno Atoll, legit Leonard Horwitz, Aug. 19, 1951; CAROLINE ISLANDS—D. 15897.6, tetrasporic, on dead coral reef at Quoi I., Truk Islands, legit E. Menez, July 30, 1960; D. 21708.5, reef flat, Epwelkapw, Ponape I., legit E. Menez, Aug. 18, 1960; D. 21740.1, on dead coral, reef on the eastern side of Mantapeitak I., legit E. Menez, June 20, 1960; D. 23154.1, on dead coral, reef at Yap I., legit E. Menez, Aug. 19, 1960; PHILIPPINE ISLANDS—D. 18213, on *Acanthophora*, Mawes, Hinatuan, Surigao, legit E. Menez, July 7, 1958; D. 18138, on rocks, reef flat at a depth of 3 ft, near Davao, Mindinao, legit E. Menez, June 22, 1958; INDONESIA—in the Rijksherbarium at Leiden, a collection by G. A. L. de Haan, No. 30, Sumatra, Aug. 24, 1957; a Siboga Expedition collection in the Rijksherbarium, from coral, Maumeri, Flores I. (8–9° S, 110–120 E), 1880, along with *Lophosiphonia cristata*. The latter was identified by Weber-van Bosse as *L. obscura* (Ag.) Falk.

Mention should be made of two collections by Dawson from ATLANTIC CENTRAL AMERICA Da. 24356, south of Portete, Costa Rica, Aug. 4, 1962; Da. 21910, Golfe de Fonseca, El Salvador, Aug. 7, 1960.

A variant form is represented by G. 502, abundant on *Halimeda* sp. at a depth of about 19 m in the lagoon at Eniwetok Atoll, Marshall Islands, collected Aug. 29, 1955. It differs in the following respects: (1) scar-cells occur one per segment throughout; (2) the pericentral cells are hardly oblique; (3) the rhizoids arise $\frac{1}{4}$ the length of the pericentral cell from its distal end; (4) the tips of the rhizoids are discoid, with a lobed apex to which the separate marginal cells are attached; (5) trichoblasts are unbranched or with a single branch and with a very long basal cell (to 240 μ long); (6) the erect branches tend to arise in pairs with 4 segments between corresponding members of successive pairs. G. 781 is similar to the preceding in a number of the variant features. It was likewise growing on a *Halimeda* sp. at a depth of 5.3 m in the lagoon, Eniwetok Atoll. It was collected Sept. 7, 1955. D. 13464.1 likewise represents this variant form in most respects. It was collected from a basalt ledge on

the west lip of Pohoiki Bay, Puna, Island of Hawaii, Nov. 10, 1956.

Characteristic features of this low matted species are: the rhizoids with multicellular tips arising at the distal end of the pericentral cells, and the more or less oblique position of the pericentral cells, which are periclinally flattened.

Polysiphonia sparsa (Setchell) comb. nov.

Lophosiphonia sparsa Setchell (1926:103)

Figs. 5D, 23, 40

Epiphytic algae to 1 cm high from prostrate branches attached by relatively large unicellular rhizoids cut off by a cross-wall from the proximal end of the pericentral cells and often with finely digitate tips; plants relatively stiff, with 4 ecorticate pericentral cells and with segments mostly 0.2–0.5 diameter long and 200–280 μ in diameter in median parts of main branches; trichoblasts one per segment in $\frac{1}{4}$ spiral sequence; usually poorly developed but sometimes to 650 μ long with 3–5 dichotomies and up to 9 cells in length of longest axis, with very delicate tips, soon deciduous, leaving small scars and often prominent wall scars; branches arising independent of trichoblasts, with mostly 7–12 segments between successive branches; tips of branches acutely pointed; leading axes commonly distinct, the branching mostly not at all dichotomous, at least near apices; tetrasporangia 80–85 μ in diameter, spiralling in the ultimate and subultimate branches and eventually distending the segments somewhat; cystocarps to 330 μ in diameter, nearly spherical, with very short, broad attachment and pericarp of relatively large cells 30–40 μ in diameter; spermatangial branches arising as a primary branch of a trichoblast without sterile tip.

COLLECTIONS STUDIED: HAWAIIAN ISLANDS—D. 19144Q3, D. 19145AF, dredged 6–13 fa and 40–85 fa respectively, Port Allen, Kauai, Sept. 12, 1959; an unnumbered collection by G. F. Papenfuss, from near the Elks Club, Waikiki, Oahu, Apr. 1, 1942; SOCIETY ISLANDS—D. 12104, tetrasporic, among and attached to turf-forming corallines, near Arue Pt., Arue, Tahiti, Nov. 15, 1952; D. 14693, legit J. Randall, on corallines, reef flat, Matavai Bay, Tahiti, Apr. 2, 1956; PHOENIX ISLANDS—O. Degener 24866A, tetrasporic, Canton Atoll,

Feb. 18, 1958; L. 2434.8, McKean I., Oct. 19, 1964; MARSHALL ISLANDS—D. 9536H, scraped from a flat rock near the edge of the reef, transect area Arno Atoll, legit Leonard Horwitz, Aug. 10, 1951; H. 48–0290.4, inner reef, Eric I., Bikini Atoll, July 13, 1948; H. 48–1091.16, outer reef, Arji I., Bikini Atoll, July 12, 1948; H. 48–1213.1, tetrasporic, Amen I., Bikini Atoll, Aug. 7, 1948; H. 48–2894.7, on other algae, Nama I., Bikini Atoll, July 15, 1948; PHILIPPINE ISLANDS—two unnumbered collections by D. P. Abbott, 1957: Laa Tawitawi, Sulu Sea, Feb. 12; south end of Gnat Reef, Balabac I., Sulu Sea, Mar. 4, 1957.

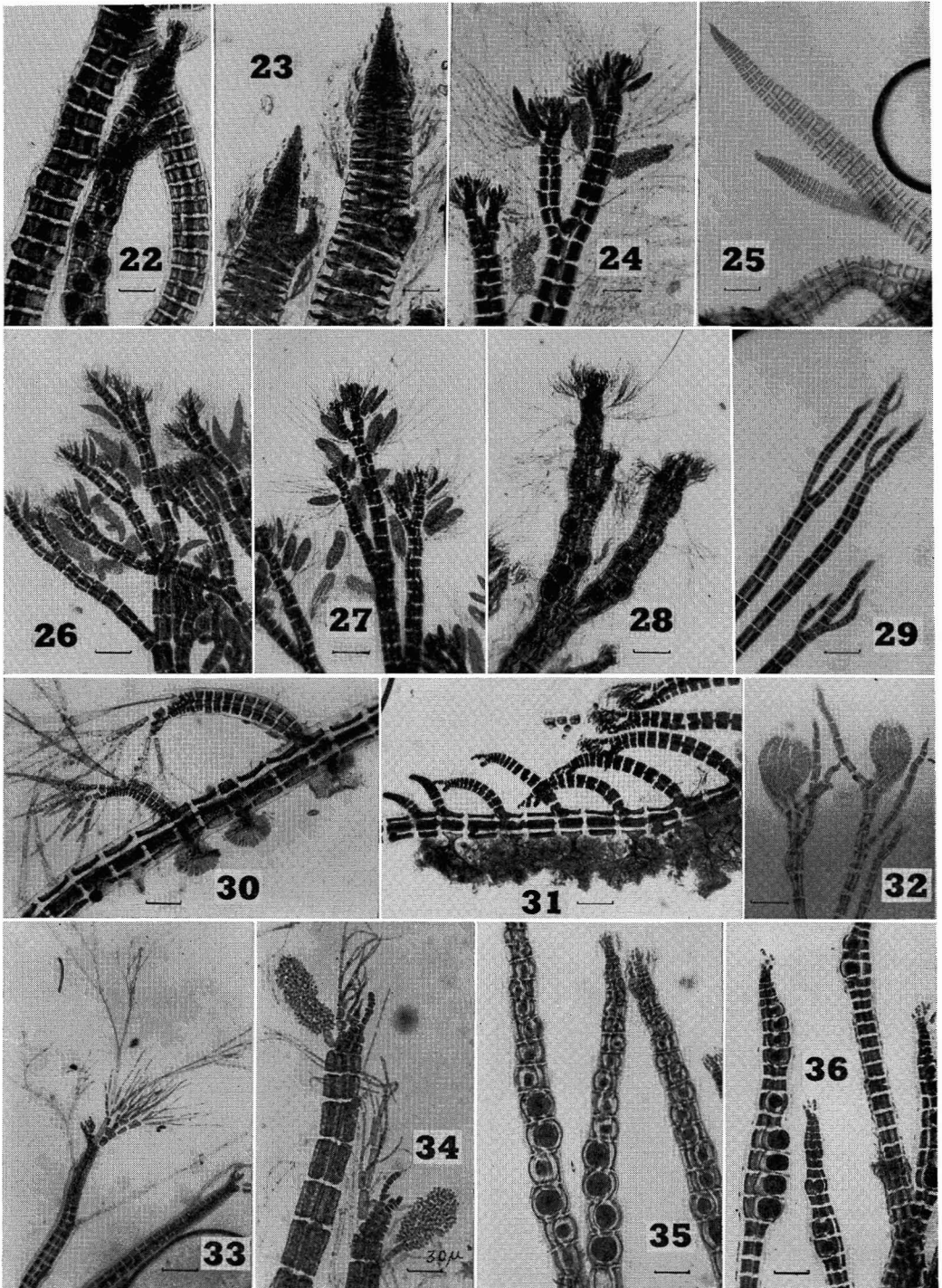
Examination of the type of *Lophosiphonia sparsa* Setchell, kindly loaned from the herbarium of the University of California at Berkeley, leads the writer to conclude that the specimens listed above are to be identified with this species, which for reasons presented in the introductory paragraphs of this paper is more properly placed in the genus *Polysiphonia*.

It seems likely that specimens of this species have been sometimes identified as *P. ferulacea*. However, *P. sparsa* is a much smaller plant with much shorter segments especially in terminal branches, and has spermatangial branches without the sterile tips, seemingly characteristic of *P. ferulacea*.

Polysiphonia sphaerocarpa Boergesen (1918: 271)

P. pulvinata Menez (1964:215) = *P. pulvinata* Segi (1951:195) non *Conferva pulvinata* Roth (1797:187), non *P. pulvinata* Kützing (1863:12), non *P. pulvinata* (C. Agardh) J. G. Agardh

Intertidal tufted algae mostly 0.5–1.5 cm high from prostrate branches of limited extent (80)–100–200 μ in diameter, attached by unicellular rhizoids, which are cut off as separate cells from the pericentral cells; erect branches assurgent to cicatrigenous, mostly 100–180 μ in diameter, with segments mostly 1.0–1.5 diameters long, pseudodichotomously branched in a somewhat flabellate manner; branches arising independent of trichoblasts, at intervals of 7–11 segments; pericentral cells 4, ecorticate; trichoblasts one per segment in $\frac{1}{4}$ spiral sequence, 100–200–(580) μ long with mostly 3–4 dichot-



FIGS. 22-36. (Scale = 100 μ , except as indicated.) 22, *Polysiphonia poko* var. *longii*, tip of tetrasporangial branch of the type specimen. 23, *Polysiphonia sparsa*, vegetative branch tip. 24, *Polysiphonia sphaerocarpa* var. *filifera*, with spermatangial stichidia. 25, *Polysiphonia quadrata*, vegetative branch tip from the type

omies; scar-cells small, frequently present on prostrate branches; wall-scars rarely present at the former point of attachment; tetrasporangia to 70 μ in diameter in spiral sequence in ultimate and subultimate branches; cystocarps globular, 250–350 μ in diameter, with cells of the ostiolar rim distinctly enlarged; spermatangial branches cylindrico-conical 140–170–(290) \times 40–60 μ , mostly without sterile tips, arising as a primary branch of a trichoblast.

TYPE LOCALITY: St. Thomas Island in the Virgin Islands. As represented in the tropical Pacific Ocean this is a very variable species. It has been identified by Menez (1964) and other investigators as *P. pulvinata* (C. Agardh) J. G. Agardh (i.e., *Hutchinsia pulvinata* C. Agardh). According to Boergesen (1930:85), "*Hutchinsia pulvinata* C. Ag., and most probably *Conferva pulvinata* Roth, both quoted by Montagne, have 6 pericentral cells, as pointed out by Bornet [1892:306], who probably examined Roth's specimens."

The writer examined five specimens from the Kützing herbarium identified as *P. pulvinata* C. Agardh. Cross sections showed that two of these have 6 pericentral cells. The other three have 4 pericentral cells. In none of the five specimens do the scar-cells occur regularly on each segment as in the various specimens from the tropical Pacific Ocean. One of those with 4 pericentral cells bears the notation "a comunicat ex herbario J. G. Agardh."

The writer's observations and those of Boergesen seem to indicate that the specimens herewith identified as *P. sphaerocarpa* Boergesen cannot be identified with *P. pulvinata* (C. Agardh) J. G. Agardh.

Although *Conferva pulvinata* Roth has priority, Roth's specimens, unfortunately, are not available for study, having been destroyed during the second World War. On the other hand the writer examined a prepared mount and fluid-preserved material of the type of *P. sphaerocarpa* kindly loaned from the herbarium at the University of Copenhagen and found the Pacific specimens to agree in all basic details with the type of Boergesen's species, although the Pacific plants exhibit much more variability than Boergesen's description would indicate.

Taylor (1960) describes *P. sphaerocarpa* as "a reef plant growing in exposed places." Those so identified from the Pacific are of similar habitat. A number of collections by Dr. A. J. Bernatowicz from Bermuda, identified as *P. sphaerocarpa*, were found to correspond closely in most respects with the Pacific specimens, including the enlarged cells of the rim of the ostiole of the pericarp.

P. sphaerocarpa as described herewith seems close to *P. simplex* Hollenberg (1942b:782), but the latter plant is often larger and is basically prostrate, with assurgent branches, whereas *P. sphaerocarpa* is tufted erect with limited prostrate branches.

KEY TO THE VARIETIES OF *Polysiphonia sphaerocarpa*

1. Segments in median parts of leading branches mostly about 0.5 diameter long; trichoblasts well developed and relatively persistent var. *filifera*
1. Segments in median parts of leading branches mostly about 1 diameter long; trichoblasts mostly less well developed and soon deciduous 2
2. Lateral branches abundant, at intervals of 5–12 segments var. *sphaerocarpa*
2. Lateral branches commonly at intervals of 20 or more segments var. *distans*

slide. 26, *Polysiphonia sphaerocarpa* var. *sphaerocarpa*, a variant form with enlarged spermatangial stichidia, with proliferating apices. 27, *Polysiphonia sphaerocarpa* var. *filifera*, with spermatangial stichidia. 28, *Polysiphonia sphaerocarpa* var. *filifera*, tetrasporic. 29, *Polysiphonia upolensis*, vegetative branch tips. 30, *Polysiphonia scopulorum* var. *scopulorum*, prostrate branch, with young erect branches and rhizoids, attached to a firm substratum. 31, *Polysiphonia scopulorum* var. *scopulorum*, prostrate branch, with young erect branches and rhizoids attached to a porous, soft substratum. 32, *Polysiphonia rubrorhiza*, erect branch tips, with cystocarps (type material). 33, *Polysiphonia scopulorum* var. *scopulorum*, tips of erect branches. 34, *Polysiphonia scopulorum* var. *minima*, tips of erect branches bearing spermatangial stichidia (from the type collection). 35, *Polysiphonia upolensis*, tips of tetrasporangial branches, tetrasporangia in spiral series. 36, *Polysiphonia scopulorum* var. *scopulorum*, tips of erect branches with tetrasporangia in straight series.

P. sphaerocarpa var. *sphaerocarpa*
Figs. 21, 26

MATERIAL EXAMINED (Those marked with an asterisk are more slender with segments often to 2 diameters long and with lateral branches slightly to distinctly narrowed at the base; see Figure 21): HAWAIIAN ISLANDS—D. 13355*, tetrasporic, cystocarpic, spermatangial, awash, Sans Souci Beach, Waikiki, Oahu, Oct. 2, 1956; D. 19121L1, cystocarpic, dredged 15–26 fathoms, Pokai Bay, Oahu, Aug. 1, 1959; D. 19624.1, cystocarpic, Kahanahaiki, Oahu, Jan. 27, 1962; a collection* by Isabella Abbott, tetrasporic, cystocarpic, on *Laurencia* sp. and corallines, Ewa Beach, Oahu, Mar. 17, 1946; H. 62–3, tetrasporic, cystocarpic, on *Acanthophora*, Sans Souci Beach, Waikiki, Oahu, Dec. 12, 1962; a collection by G. F. Papenfuss, tetrasporic, Hanauma Bay, Oahu, Mar. 1, 1942; W. A. Setchell, 10403, cystocarpic, Mokuauia I., off the northeast coast of Oahu, July 14, 1924; D. 19738A2, tetrasporic, on rocks, Halena, Molokai, Dec. 27, 1953; D. 17184A1, southwest of Kaimu Bay, Island of Hawaii, Feb. 27, 1953; D. 17197A1, tetrasporic, with other algae, Kalapana Beach, Kaimu Bay, Hawaii I., Feb. 2, 1953; H. 65–6.5, tetrasporic, in algal turf, Kona District, Hawaii, legit M. Kajimura, Jan. 29, 1965; TUAMOTU ARCHIPELAGO—D. 11059.1*, tetrasporic, on coral reef opposite Ngarumaoa Village, Raroia Atoll, legit M. S. Doty and Jan Newhouse, July 8, 1952; AMERICAN SAMOA—all but the last legit R. Buggeln, 1964: T. 717, cystocarpic, on wave-washed basalt at the mouth of Fagasa Bay, Tutuila I., Aug. 21; T. 732, spermatangial, on *Laurencia* sp., wave-washed shore, Vista Bay, Tutuila, Aug.; T. 735B, tetrasporic, on wave-washed shore, Vatia Bay, Tutuila I., Aug. 1; T. 841, tetrasporic, cystocarpic, on wave-dashed shore, in small tidepools, Onenoa, Tutuila, Aug. 6; W. A. Setchell, 1068 (C. 237033), as *P. tongatensis* Harvey, legit F. A. Potts, from a buoy, Pago Pago Harbor, June 10, 1920; GILBERT ISLANDS—D. 18780, cystocarpic, *P. fragilis* as interpreted by Tsuda (1964) on the reef south of Rawanawi Village, Marakei Atoll, legit M. J. Cooper, July, 1962; MARSHALL ISLANDS—H. 48–9514.2, tetrasporic, cystocarpic, on *Boodlea* sp., inner shore, Nama I., Bikini Atoll, July 15, 1948; CAROLINE ISLANDS—D. 23621, on

the reef at Utwa Village, Kusiae I., legit E. Menez, July 17, 1960.

P. sphaerocarpa var. *distans* var. nov.
Fig. 5E

Plants as in the species but with intervals of (8)–20–25 or more segments between successive branches and with chromatophores mostly aggregated on the inner wall of the pericentral cells; trichoblasts relatively coarse, to 365 μ long.

Plantae ut in species descriptae, intervallis, autem (8)–20–25 vel plurim segmentorum inter ramos successivos, et chromatophoris in pariete interiore cellularum pericentralium plerumque aggregatis; trichoblastae relative grossae, ad 365 μ long.

TYPE: D. 12384, tetrasporic, cystocarpic, awash, Sans Souci Beach, Waikiki, Oahu, Hawaii, Feb. 6, 1954.

ADDITIONAL COLLECTIONS: D. 19534, tetrasporic, cystocarpic, Hanauma Bay, Oahu, Apr. 6, 1952. A collection, III BA, spermatangial, by T. A. and Anne Stephenson, Plantation Keys, Florida, in 1957, seems identical in most details with the Pacific specimens, including the distant branches and the position of the chromatophores, although the branches are at somewhat closer intervals in the case of the Florida specimen. Stephenson III Bb from the same locality is very similar, although coarser, and the spermatangial branches terminate in a globular sterile cell very much like those figured by Boergesen (1918: Fig. 279) for a plant he identified as *P. ferulacea*. This type of male structure has been seen several times in plants identified by the writer as *P. ferulacea*, although the plants bearing them were in other respects distinct from *P. sphaerocarpa*.

Another variant of *P. sphaerocarpa* with a sterile tip on spermatangial structures is represented by T. 538, cystocarpic and T. 539, tetrasporic and cystocarpic, on other algae in tidepools, Laysan I., (25° 42' N, 171° 44' W) Dec. 6, 1963; T. 934B, tetrasporic on coral reef, Trig I., French Frigate Shoal, legit C. R. Long, Sept. 27, 1964.

Still another variant is represented by the following: D. 13014.2, male, on reef near

Koloa, Oahu, Oct. 30, 1955; D. 17184AE, cystocarpic, on the southwest end of Kaimua Bay, Island of Hawaii, Feb. 27, 1953; D. 17332.1, immature male, $\frac{1}{4}$ mile southwest of Opihikao, Puna, Island of Hawaii, Jan. 27, 1953; T. 749, T. 731, T. 732, spermatangial, and T. 735A all collected by R. Buggeln from coral and basalt, Vatia Bay, Tutuila I., American Samoa, Aug. 1964. This variant is characterized by segments of main branches, which are mostly less than 1 diameter long, and by relatively small spermatangial branches to 110μ long bearing a sterile tip composed of a single small cell 1–3 diameters long. In the latter respect this variant is similar to a specimen of *P. sphaerocarpa* collected by S. Carlquist at Grayson's Cove, Saccora I., off the coast of Lower California, Mexico, May 4, 1955. However, in the Mexican specimen the sterile tips of the spermatangial branches are up to 280μ long and composed of 3–4 cells. Tsuda's specimens from Samoa and the Mexican specimen are closer to var. *sphaerocarpa* in having short segments and in having intervals of 6–7 segments between successive branches. An unusual variant with respect to the spermatangial branches is represented by H. 65–6.6, cystocarpic and spermatangial, with very delicate trichoblasts and with spermatangial branches mostly very large and lanceolate in shape, with a short polysiphonous terminal extension, which bears short lateral trichoblasts (Fig. 26). This specimen was collected at Kahala Park, Honolulu, Hawaii, Feb. 25, 1965. It may represent a case of teratology. This variant is likewise closer to var. *sphaerocarpa* in other respects.

P. sphaerocarpa var. *filifera* var. nov.

Figs. 10, 24, 27, 28

Epiphytic or saxicolous with segments of erect branches mostly ca. 0.5 diameter long, with relatively long and persistent trichoblasts, and generally a more extensive prostrate branching system. The variety bears considerable resemblance to *P. poko* but usually has much-branched erect branches, whereas the erect branches of *P. poko* are mostly unbranched. Thus far this variety has been collected almost exclusively in the Hawaiian Islands, where it is very common.

Plantae epiphyticae aut saxicolae, proprietates speciei generales habentes, segmentis, autem, ramorum erectorum ca. 0.5 brevioribus quam lata, trichoblastis

relative longis persistentibusque, ramificatione prostrata plerumque ampliore.

TYPE: D. 22532, tetrasporic, cystocarpic, on algal turf near Honokohau, Maui, Hawaii, legit H., T., and B., Apr. 20, 1965.

ADDITIONAL COLLECTIONS STUDIED: D. 20131, on other algae, Guam, legit E. Menez, Oct. 12, 1960; D. 12692, cystocarpic, male, on *Helminthocladia*, at a very low tide level, Waianae, Oahu, legit Jan Newhouse and Henry Kekoanui, Jan. 2, 1954; D. 12782, tetrasporic, cystocarpic, male, on *Chondria* sp., Haleiwa Army Beach, Haleiwa, Oahu, legit Elvin Fong, Apr. 25, 1955; D. 13442, tetrasporic, intertidal basalt, west lip of Pohoiki Bay, Puna district, Island of Hawaii, Nov. 10, 1956; D. 19315.1, cystocarpic, male, Makua Beach, leeward Oahu, Jan. 21, 1962; D. 17932.5, tetrasporic, cystocarpic, above low tide level at the east end of Maile Beach, Lualualei, Oahu, Apr. 11, 1959; D. 19618, tetrasporic, male, Kahanahaiki, Waianae, Oahu, Jan. 27, 1962; H. 65–61.5, cystocarpic, in algal turf, Wawamalu Beach, Oahu, May 1, 1965; a collection by G. F. Papenfuss, cystocarpic, male, between Halona and Kaloko, Oahu, Mar. 29, 1942; H. 65–3, tetrasporic, cystocarpic, male, upper littoral, opposite Kaneana Cave, leeward Oahu, Jan. 1, 1965; H. 65–8.5, tetrasporic, cystocarpic, male, upper littoral on basalt, northeast of Waialae Bay, southeastern Oahu, Feb. 13, 1965; H. 65–10, tetrasporic, cystocarpic, on *Laurencia*, Makaha Pt., Oahu, Feb. 28, 1965; D. 22383.1, tetrasporic, male, in algal turf, basalt shore, southwest of Maalaea, Maui, legit H., T., and B., Apr. 19, 1965; D. 22423.1, tetrasporic and D. 22442, tetrasporic, cystocarpic, sandy beach near Camp Pecusa, Olowalu, Maui, legit H., T., and B., Apr. 19, 1965; D. 22484.1, male, basalt reef north of Kahana, Maui, legit H., T., and B., Apr. 20, 1965; D. 22549.2, tetrasporic, intertidal on *Pocockiella* growing on large boulders, Kahakuloa, Maui, legit H., T., and B., Apr. 21, 1965; D. 20165.1, tetrasporic, 1.3 cm high, with trichoblasts of variable coarseness, in algal turf in tidepools, Kamoamo, Puna District, Island of Hawaii, Mar. 21, 1965 (somewhat larger and coarser than most of the collections of this variety); D. 20158, tetrasporic, on *Hypnea*, in tidepools, Kamoamo,

Puna district, Hawaii, Mar. 21, 1965; H. 65-12.5, cystocarpic, on other algae, Kapoho, Hawaii, legit John Fitzsimons, Mar. 1, 1965.

Polysiphonia subtilissima Montagne (1840:199)
Fig. 19

Plants to 4 cm high, from prostrate branches attached by relatively long, unicellular rhizoids, often with lobed tips, which remain in open connection with the pericentral cells; erect branches 70-130 μ in diameter in median parts, with lateral branches arising independent of trichoblasts at intervals of 5-8-(14) segments, and with frequent endogenous branches arising from prostrate branches; segments in the main branches mostly 1.0-1.5 diameters long; pericentral cells 4, ecorticate; cell walls mostly thin and hyaline, except in lower parts where they may be considerably thickened, to 11 μ ; apical cells relatively large; trichoblasts infrequent and usually poorly developed and unbranched but occasionally to 400 μ long, with 1-2 dichotomies, tapering to delicate tips, but relatively straight and stiff, soon deciduous leaving inconspicuous scar-cells; reproductive structures not observed in the materials studied.

Although usually sterile and smaller than the species elsewhere, Pacific specimens correspond closely to the features generally attributed to the species, except that the rhizoids although mostly long are not particularly coarse as described by Taylor (1960) for the species in Atlantic waters. Found mostly in slightly brackish water.

TYPE LOCALITY: Cayenne, French Guiana, northern South America. All but one of the collections identified with this species are from the island of Oahu, Hawaii. This probably indicates a lack of collections from suitable localities elsewhere.

P. subtilissima var. *subtilissima*

COLLECTIONS STUDIED: M. 710, 711 (BISH), at a depth of 4.3 ft, along the bank of Waipuhi stream, Kamehameha Highway bridge, near Kaneohe, Feb. 24, 1961; M. 727, 728A (BISH), from basalt rock wall, Waipuhi stream near Hauula School, Feb. 24, 1961; D. 14695, on rocks, south end of Salt Lake, Honolulu, Hawaii, early Jan. 1964; C. 696325, legit Cyril Crossland 6721, Marquesas Islands, 1923-24.

P. subtilissima var. *abbottae* var. nov.

Figs. 5F, 6A

With the features of the species but with longer segments (2-2.5 diameters long) in median parts of the main branches, with more slender main branches (50-70 μ in diameter), and with abundant and relatively persistent slender trichoblasts to 600 μ long and 6-9 μ in diameter at the base, composed of relatively long cells, arising at intervals of 2-3-(12) segments; reproductive structures unknown.

Varietas proprietates speciei habens, segmentis, autem, longioribus (2.0-2.5 plo longioribus quam lata) in ramis principalibus qui tenuiores (50-70 μ diam) et trichoblastas tenues abundantes relative persistentes, ad 600 μ long., 6-9 μ diam ad basim habent; trichoblastae e cellulis relative longis, intervallis 2-3-(12) segmentorum enascentibus compositae; structurae reproductivae ignotae.

The type and only known collection of this variety was collected from the shores of Salt Lake, Oahu, and reported by Isabella A. Abbott, No. 1757. The water in this pond was described by Abbott (1947) as nearly fresh. Abbott gave two figures (13A, B), but did not assign the plant to a definite species on account of the lack of reproductive structures. The habitat and the nature of the rhizoids strongly suggest placement in *P. subtilissima*. The most distinctive feature of the variety is the abundance of trichoblasts. Rhizoids remain in open connection with the pericentral cells and tend to arise in more or less whorled arrangement (Fig. 6A).

P. subtilissima Segi (1951:197) cannot be identified with Montagne's species if the Hawaiian specimens and the specimens from the southeast coast of the United States mainland are properly identified. Segi's Figure 8A shows rhizoids cut off as separate cells, a feature indicative of another species.

Polysiphonia tenuis sp. nov.

Figs. 6B, 6C

Minute algae with creeping branches 30-35 μ in diameter, composed of segments about 1 diameter long and attached by unicellular rhizoids, which are cut off from the pericentral cells as separate cells; without scar-cells on the prostrate branches; erect branches to 2 mm high, unbranched, 28-35 μ in diameter, with segments mostly 1.5-(2.0) diameters long, arising endog-

enously at frequent intervals; pericentral cells 4, ecorticate; trichoblasts to 800 μ long with 2–4 dichotomies and with basal cells to 260 μ long and 30 μ in diameter, and with very delicate tips, arising one per segment in terminal parts of erect branches but at intervals of 2–3 segments in lower parts; tetrasporangia in short spiral series near branch tips; cystocarps urceolate, 140–150 μ broad and 190–220 μ long, on the middle and upper parts of erect branches; spermatangial branches 100–130 μ \times 35–50 μ , without sterile apices, arising from the entire trichoblast primordium.

Algae minutae ramos repentes 30–35 μ diam., composites e segmentis ca. aequae longis ac lactis, habentes, per rhizoidea unicellularia, ut cellulas discretas a cellulis pericentralibus separata, affixae; sine cellulis-cicatricibus in ramis prostratis; rami erecti ad 2 mm alt., non ramosi, 28–35 μ diam., segmentis 1.5–(2.0) longioribus quam lata, intervallis frequentibus endogene nascentes; cellulae pericentrales 4, ecorticate, trichoblastae ad 800 μ long., 2–4 dichotomias habentes, cellulis basalibus ad 260 μ long. atque 20 μ diam., una in unoquoque segmento in partibus terminalibus, intervallis, autem, 2–3 segmentorum in partibus inferioribus; tetrasporangia in serie spirali brevi; cystocarpi urceolati, 140–150 μ lat. atque 190–220 μ long.; rami spermatangiales 100–130 μ \times 35–50 μ , sine cacuminibus sterilibus, e primordio toto trichoblastae enascentes.

TYPE: H. 65–105.1 is the only collection. It is represented by 6 glucose mounts and some fluid-preserved material. It was growing on dead coral and was collected by R. S. Jones at a depth of 1–2 m and 20 m shoreward from the outer reef margin north of North I., Johns Island, Apr. 22, 1965.

This is another minute plant resembling *P. scopulorum* in habit, in endogenous origin of erect branches, and spermatangial branches arising from the entire trichoblast primordium. From *P. scopulorum* it differs in the rhizoids which are cut off as separate cells and in the occurrence of tetrasporangia in spiral series. From *P. pseudovillum* it differs in the endogenous origin of branches and in the spermatangial branches.

Polysiphonia tuberosa sp. nov.

Figs. 3D, 3E, 39

Minute epiphytes with limited to extensive prostrate branches 45–80–(100) μ in diameter,

frequently with local portions of prostrate branches conspicuously swollen and filled with what appears to be food reserves; attached by unicellular rhizoids cut off from the pericentral cells as separate cells; erect branches assurgent or endogenous, to 12 mm high and 50–65 μ in diameter with segments 1.5–2.0 diameters long, mostly with infrequent lateral branches, at intervals of 7–20–(30) segments; pericentral cells 4, ecorticate; trichoblasts few and not well developed or frequently long (to 500 μ) and with 2–3 dichotomies and a basal cell up to 140 μ long; scar-cells at intervals of 1–2 segments on erect branches, mostly lacking on prostrate branches; erect branches mostly or all endogenous, lateral branches cicatrigenous, sometimes appearing to arise in connection with a trichoblast, when in fact the branch arises from the potential scar-cell bearing the still persistent trichoblast; tetrasporangia to 58 μ in diameter, in short straight series, much distending the segments; spermatangial branches arising as a primary branch of a trichoblast.

Algae epiphyticae minutae, ramis prostratis praefinitis ad late patentes, 48–80–(100) μ diam., horum partibus localibus manifeste tumidis et, ut videtur, nutrimento reservato plenis; plantae per rhizoidea unicellularia, a cellulis pericentralibus et cellulas discretas separata, affixae; rami erecti assurgentes aut endogeni, ad 12 mm alt., 50–65 μ diam., segmentis 1.5–2.0 plo longioribus quam lata, plerumque rarios ramos laterales, interdum, autem, aliquot ramos laterales intervallis 7–20–(30) segmentorum habentes; cellulae pericentrales 4, ecorticate; trichoblastae paucae necnon male evolutae, aut saepe longae (ad 500 μ) et 2–3 divisiones atque cellulam basalem usque ad 140 μ long. praebentes; cellulae-cicatrices intervallis 1–2 segmentorum in ramis erectis, in ramis prostratis maxime ex parte carentes; rami erecti plerique omnesve endogeni, rami laterales cicatrigeni, interdum in associante cum trichoblasta ut videtur enascentes, cum enim rami e cellula-cicatrici potenciali trichoblastam etiam persistentem ferente, enascent; tetrasporangia ad 58 μ diam., in serie brevi rectaque, segmenta multum distendentia; rami spermatangiales ut ramus primarius trichoblastae enascentes.

TYPE: D. 19137N1, sterile, dredged 15–20 fa, off Ilio Pt., Molokai, Hawaii, Sept. 7, 1959. Represented by a glucose slide mount.

ADDITIONAL COLLECTIONS (all from Hawaii): D. 19134AC2, on *Sargassum*; D. 19134H1, on *Amansia*, all from 25 fa near a channel buoy, Kaneohe Bay, Oahu, July 15,

1959; D. 19116Q1, on *Hypnea*, Pokai Bay, Oahu, Sept. 15, 1959; D. 19140D1, from 31–32 fa, Penguin Bank southwest of Molokai, Sept. 7, 1959. A collection by Dawson No. 7472 from Lake Surprise, Key Largo, Florida, May 28, 1949, has a number of features in common with the Hawaiian specimens.

The minute size, delayed exogenous branching, and frequently tuberous prostrate branches are the chief distinguishing features of this species.

Polysiphonia upolensis (Grunow) comb. nov.
Figs. 6D, 6E, 29, 35, 42

P. tongatensis? var. *upolensis* Grunow (1873: 49)

Plants 1–2–(3) cm high from limited to extensive creeping branches attached by unicellular rhizoids, which often have finely digitate tips, and which are cut off as separate cells from the pericentral cells; rhizoids often conspicuously swollen in the middle, to 95 μ in diameter; prostrate branches 70–140 μ in diameter, composed of segments mostly 1.0–1.5 diameters long and slightly nodose; erect branches assurgent or arising cicatrigenously from prostrate branches, 100–120 μ in diameter and composed of segments (1)–1.5–2.0 diameters long and usually not at all nodose, pseudodichotomously branched at wide angles below and narrower above, at intervals of 14–20–(50) segments, the branches arising exogenously, independent of trichoblasts or occasionally cicatrigenously; pericentral cells 4, ecorticate; trichoblasts 200–340–(700) μ long, delicate, measuring 8–10 μ in diameter at the base, with 1–3–(4) dichotomies and with delicate tips, arising at intervals of (1)–2–3 segments in $\frac{1}{4}$ spiral sequence, soon deciduous; scar-cells relatively small, on prostrate and erect branches, and with no obvious wall scars; tetrasporangia 60–80 μ in diameter in slightly spiral series in the ultimate and subultimate branches;

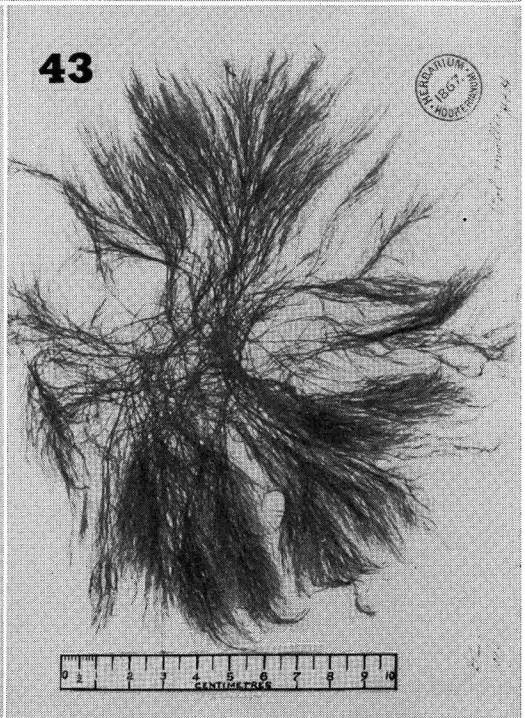
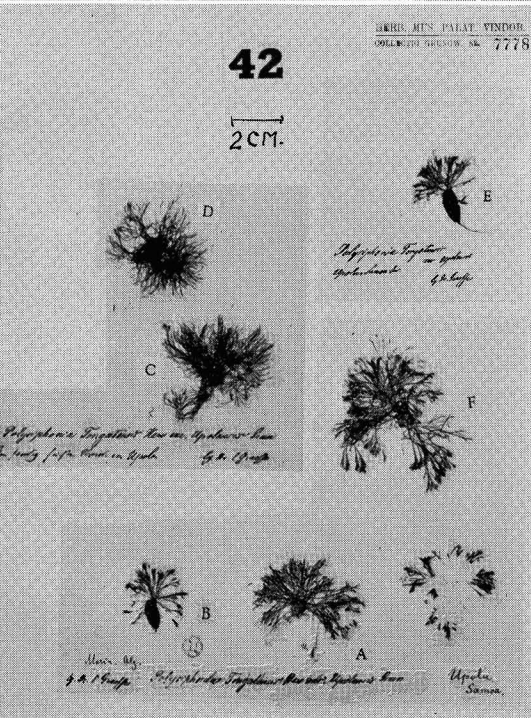
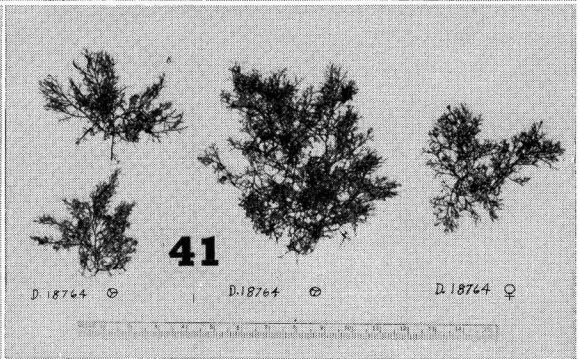
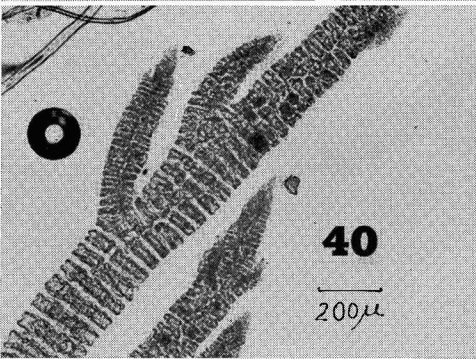
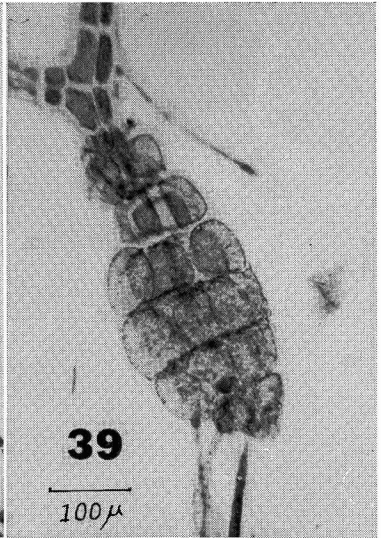
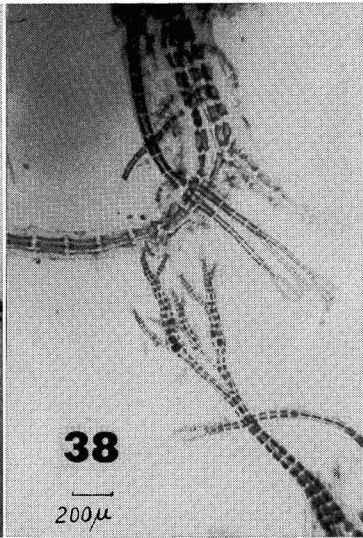
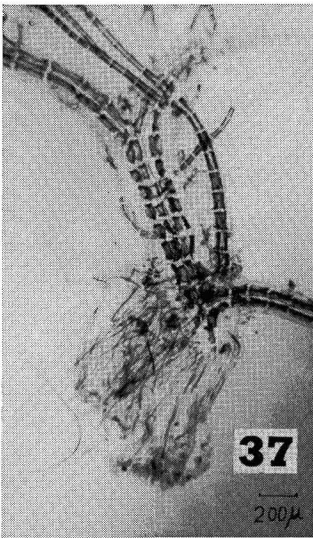
cystocarps globular to slightly ovoid, 150–200–(275) μ in diameter, with cells of the ostiolar rim not noticeably enlarged; spermatangial branches 130–190 \times 22–30 μ commonly with 1–2-celled sterile tips; arising as a primary branch of a trichoblast.

The type material from the Grunow Herbarium at the Natural History Museum, Vienna, was collected by Dr. E. Graeffe at Upolu, British Samoa. This material consists of six herbarium sheets on which are mounted 11 separate specimens accompanied by five glass microslide mounts (dried) and three sketches of detailed features, presumably by Grunow. Herbarium sheet 7778 probably is most representative of the collection and is reproduced in Figure 42A–F. It will be noted that two of the specimens are attached to leaves of a species of *Halophila*. Two were growing on *Halimeda* sp.

Examination of the type specimens reveals the same detailed features found in the numerous collections listed below. The plants of the type collection are 2–3 cm high, branches arise at intervals of 10–20 segments. Scar-cells occur mostly at intervals of 2 segments. Tetrasporangia occur in a slightly spiral series of 30–40 segments. The cystocarps are globular to 230 μ in diameter with cells of the rim of the ostiole not enlarged, and spermatangial branches are 200–220 μ long, lanceolate, with a small, mostly one-celled, sterile tip.

ADDITIONAL COLLECTIONS EXAMINED: HAWAIIAN ISLANDS—D. 19576C, on other algae Kure I. (near Midway I.) Sept. 12–13, 1961; T. 906, on *Microdictyon*, in beach drift, Southeast I., Pearl and Hermes Reef, Sept. 16, 1964; D. 22289.2, tetrasporic, cystocarpic in algal mat, low intertidal, Kahe Pt. Beach Park, Oahu, legit R. Tsuda and R. Buggeln, Jan. 30, 1965; D. 22570, on rocks under low bridge at outer end of an old rock pier, eastern Molokai, legit G. Hollenberg, Apr. 22, 1965; D. 17946.1, Maui, legit T. Matsui, Apr. 11, 1959; D. 22365,

FIGS. 37–43. 37, *Polysiphonia savatieri*, photomicrograph of basal part of plant, with a basal tuft of rhizoids. 38, *Polysiphonia savatieri*, photomicrograph, showing tetrasporangia in erect branches. 39, *Polysiphonia tuberosa*, showing the tuberous base with rhizoids (the type specimen). 40, *Polysiphonia sparsa*, showing short segments of a vegetative branch. 41, *Polysiphonia hawaiiensis*, three portions of the type collection. 42A–F, *Polysiphonia upolensis*, photograph of representative specimens from the type collection. 43, *Polysiphonia mollis*, probably the type specimen (photograph by W. R. Taylor of the specimen in the herbarium of the Royal Botanic Gardens, Kew, Richmond, Surrey, England).



and D. 22369.5, both tetrasporic, cystocarpic, in algal turf and on other algae, seaward side of jetty, Maalaea, Maui, legit H., T., and B., Apr. 19, 1965; D. 13427.1, on intertidal basalt ledge, west lip of Pohoiki Bay, Island of Hawaii, Nov. 10, 1956; D. 20193.5, D. 20209.1, in algal turf, Kaena, Puna, Island of Hawaii, Mar. 19, 1965; JOHNSTON ISLAND—H. 65-106.5, tetrasporic, cystocarpic, at a depth of 1-2 m and 20 m shoreward from the outer reef margin, north of North I., legit. R. S. Jones, Apr. 22, 1965; T. 1287, at a depth of 12-13 m, legit E. Murchison, Aug. 19, 1965; LINE ISLANDS—Da. 19532, 19539, tetrasporic, Palmyra Atoll, Oct. 1958; TUAMOTU ARCHIPELAGO—D. 11215.3, tetrasporic, D. 11217A, on a stump at a depth of about 5 ft, near the lagoon reef transect, Ngarumaoa, Raroia Atoll, legit M. S. Doty and Jan Newhouse, July, 1952; SOCIETY ISLANDS—D. 12103.1, cystocarpic, Arue Point, Tahiti, Sept. 15, 1952; collections by J. Randall; D. 14699, from the reef flat, Matavai Bay, Tahiti, Apr. 2, 1956 and D. 14700 from rocks at the water's edge, Popetai Bay, Moorea, May 30, 1956; AMERICAN SAMOA—T. 678A, on *Dictyosphaeria*, in shallow water near shore, Vatia Bay, Tutuila I., legit R. Buggeln, Aug., 1964; T. 779.1, cystocarpic, male, in basalt tidepools near Onenoa, Tutuila I., legit R. Buggeln, Aug. 13, 1964; FIJI ISLANDS—D. 12122I2, cystocarpic, on *Caulerpa* sp., Navuevu Cuvu, Singtoka, Viti Levu I., Sept. 22, 1952; GILBERT ISLANDS—D. 18897A, in a shallow passage between the lagoon and the ocean, Abemmma Atoll, legit M. J. Cooper, July 1962; MARSHALL ISLANDS—D. 9215 B, tetrasporic, on coral, transect area, Ine Village, Arno Atoll, legit Leonard Horwitz, July 30, 1951; D. 18551.1, tetrasporic, Parry I., Eniwetok Atoll, Jan. 27, 1959; G. 608.1, tetrasporic, cystocarpic, male, G. 610, male, and G. 612, male, in the lagoon at a depth of 19 m, Eniwetok Atoll, Sept. 1955; CAROLINE ISLANDS (all legit Ernani Menez, June to Sept. 1960)—D. 15546.1, on *Sargassum*, D. 15556.1, cystocarpic, male, on *Sargassum*, D. 15557.1, tetrasporic, on *Padina*, D. 15559.2, tetrasporic, on *Acanthophora*, D. 15563.1 and 15566 on *Padina*, D. 15567.1, male, D. 15586.3B, tetrasporic, cystocarpic, on *Padina*, all eight collections from Koror I., Palau Group; D. 15576.1, cystocarpic, male, D. 15645.1, cystocarpic, D. 15656.1B, tetrasporic, on *Sargassum* sp., from Pulu Anna I.; D. 15721.2, D. 21737.1, tetrasporic, on dead coral, Mantapeitak I.; D. 21709.5 and D. 21838.1, tetrasporic from Epwelkapw, Ponape I.; D. 21796.5, tetrasporic, cystocarpic, eastern side of Peipalap Peak, Ponape I.; D. 21046, procarpic, south end of Moen I., Truk Islands; D. 23020, on coral pebbles on the reef at Utwa Village, Kusiae I., D. 23207.4, on *Microdictyon*, south tip of Sorol I.; D. 15879.1 and D. 23854, tetrasporic, cystocarpic, Falas I., Truk Islands; PHILIPPINE ISLANDS—D. 18070A, cystocarpic, south of Sava wharf, Davao, Mindinao, legit E. Menez, June 26, 1958; D. 18103A, on other algae at a depth of 3-6 ft, near Davao, Mindinao, legit E. Menez, June 22, 1958; D. 18227A, on *Avrainvillea*, Davao, Mindinao, June 24, 1958; several collections by D. P. Abbott, Feb.-Mar., 1958 as follows: on other algae, Tijitiji Reef, Tawitawi I., Sulu Sea; tetrasporic, southeast shore of Faganak I., Turtle Group, Sulu Sea; male, on *Tydemannia*, Laa, Tawitawi I., Sulu Sea; Calandorang Bay, Balabac; MARIANA ISLANDS—H. 65-75, awash at Agat, Guam, legit Mrs. Leonard Nelson, May, 1965. VIET NAM—Judging by Figure 60f. of Dawson (1954:455) it seems likely that his *Polysiphonia* sp., Da. 11329, is *P. upolensis*. A collection by Cyril Crossland 7259 (C. 792042), and Crossland 7153 (C. 791870) from Pa'ea, Tahiti, Jan. 1929, both identified as *P. tongatensis*, are *P. upolensis*, as is also a collection, July-Sept. 1964 by David Sigee, No. 29D, from the lagoon reef of Gan I., Addu Atoll, Maldives Islands in the Indian Ocean.

This species is very common in the Caroline Islands and the Philippine Islands. It seems closest to *P. sphaerocarpa* from which it differs in the irregular distribution of trichoblasts and scar-cells, in the lack of enlarged cells on the ostiolar rim of the pericarp, in branches arising at more distant intervals, and probably in the sterile tip of spermatangial branches.

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